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SUPERINDUSTRIA Y COMERCIO  
Radicación : 00064171 00000003  
Fecha (AMB): 2002-12-20 17:09:27  
Trámite : 002 PATENTES D  
Dependencia: 2000 DIVISION DE NUEVAS CREACIONES

TELEFONO: (57) (1) 347-3611  
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Folios: 2

Señora Jefe de la  
DIVISION DE NUEVAS CREACIONES  
Superintendencia de Industria y Comercio  
E. S. D.

TRÁMITE : 002

EVENTO : 001

ACTUACIÓN : 538

Referencia : Expediente No. 00-064.171

Asunto : Solicitud de patente para ESTRUCTURA  
ABSORBENTE POROSA CON ALTA DISTRIBUCIÓN DE  
LIQUIDOS Y METODO DE PRODUCCION

Solicitante : SCA HYGIENE PRODUCTS AB

Fecha de solicitud : 28 de agosto de 2000

Publicada en : la Gaceta No. 517 del 27 de junio de 2002

1. Yo, Emilio FERRERO, identificado como aparece al pie de mi firma, actuando como apoderado en el asunto de la referencia, atentamente, solicito se efectúe el examen de patentabilidad de la solicitud en referencia según lo establecido en el artículo 44 de la Decisión 486 de la Comisión de la Comunidad Andina. Para tal efecto presento junto con este escrito el recibo No. 02-80,900 por valor de \$318.000.00, que corresponde a la tasa fijada según lo dispuesto en la resolución No. 44691 del 31 de diciembre de 2001.

2. Ruego atentamente a la Señora Jefe se sirva ordenar que se anexe este recibo, para que se efectúe dicho examen y se continúe con el trámite de la solicitud.

Bogotá, 20 DIC 2002  
Señora Jefe,

  
EMILIO FERRERO  
T.P.A. No. 31.929

COLO 11256 801 043 6  
JBP/JFR/ID-000669/WPC11256



Industria y Comercio  
SUPERINTENDENCIA

Radicación : 00064171 00000003  
Fecha (MM/DD): 2002-12-20 17:09:27  
Trámite : 002 PATENTES D 1 REGISTRO/ 538 PETICION  
Folios: 2

NIT : 800176989-2

RECIBO OFICIAL DE CAJA : 02 - 80,900  
FECHA : DICIEMBRE 2 DE 2002

\*\*\*\*\* CONSIGNACION \*\*\*\*\*

| DEPOSITANTE       | TIPO PAGO    | BANCO         | CUENTA      | No. PAGO | FECHA PAGO | Vr. PAGO      |
|-------------------|--------------|---------------|-------------|----------|------------|---------------|
| CAVELIER ABOGADOS | CONSIGNACION | BANCO POPULAR | 050-00110-6 | 7030558  | 02/12/2002 | 20,771,000.00 |

\*\*\*\*\* CONCEPTO \*\*\*\*\*

| CANT. CONTABILITICO       | CONCEPTO                               | TOTAL CONCEPTO |
|---------------------------|----------------------------------------|----------------|
| 1 50005-01-01 SOLICITUDES | 112 PTC CAP-1 EXAMEN DE PATENTIBILIDAD | 318,000.00     |
|                           | TOTAL :                                | \$ 318,000.00  |

CEL: .CCIENTOS DIEZ Y OCHO MIL PESOS

RESPONSABLE : \_\_\_\_\_

RECIBO DE CAJA APLICADO AL EXPEDIENTE No. \_\_\_\_\_

Qto 11256-001-043-6

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**SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO**  
**DIVISION DE NUEVAS CREACIONES**

2020  
Bogotá, D.C., 6 de julio de 2005

Doctor  
**EMILIO FERRERO**  
Apoderado

Oficio No. 00005821

|               |                   |                 |
|---------------|-------------------|-----------------|
| <b>ASUNTO</b> | <b>Radicación</b> | <b>00-64171</b> |
|               | <b>Trámite</b>    | <b>002</b>      |
|               | <b>Evento</b>     | <b>001</b>      |
|               | <b>Actuación</b>  | <b>430</b>      |
|               | <b>Folios</b>     | <b>026</b>      |

Como resultado del examen de fondo, realizado con fundamento en el artículo 45 de la Decisión 486 de la Comisión de la Comunidad Andina, se le comunica:

**1. Documentos estudiados**

- Para el presente estudio se tuvo en cuenta el capítulo descriptivo que se encuentra en los folios 2 a 25, los dibujos que se encuentran en los folios 89 a 92 y el capítulo reivindicatorio que se encuentra en los folios 82 a 85 que comprende doce (12) reivindicaciones.
- De acuerdo con el folio 73 de la solicitud en estudio, se considerará la prioridad reivindicada sobre la solicitud de Suecia No. 9903072-8 del 30 de agosto de 1999.

**2. Objeto de la invención**

- La invención propuesta se refiere a una estructura absorbente en un artículo absorbente tal como un pañal, pañal pantalón, una guarda de incontinencia, una toalla sanitaria, etc., dicha estructura absorbente comprende una espuma comprimida que se expande en humedecerse. La invención se refiere además a un método de producción de un artículo absorbente que contiene una estructura absorbente de acuerdo con la invención.

En la reivindicación independiente 1 se define una estructura porosa absorbente en un artículo absorbente desechable tal como un pañal, un pañal pantalón, una guarda de incontinencia, una toalla sanitaria o similar, dicha estructura porosa absorbente comprende una porción de adquisición de líquido y una porción de almacenamiento de líquido, dicha porción de adquisición de líquido comprende una espuma de célula abierta polimérica comprimida que se expande al humedecerse, **caracterizada por que** la porción de adquisición de líquido y la porción de almacenamiento de líquido forman una unidad integrada, en la cual la porción de almacenamiento de líquido comprende una espuma de célula abierta polimérica la cual podría ser igual o diferente de la espuma en la porción de adquisición de líquido.

y que la porción de almacenamiento de líquido también contiene un material superabsorbente, en la cual la cantidad de material superabsorbente es inferior en la parte de la porción de almacenamiento de líquido que se encuentra lejos de la porción de adquisición de líquido que se encuentra en la parte de la porción de almacenamiento de líquido.

En la reivindicación independiente 11 se define un método de producción de una estructura porosa absorbente para un artículo absorbente tal como un pañal, un pañal pantalón, una guarda de incontinencia, una toalla sanitaria, una cubierta de herida, protección de camas y similares, **caracterizado por las siguientes etapas:**

Formar un material de espuma, el cual es comprimido y secado, luego  
Aplicar una solución de monómero de material superabsorbente a uno de los lados opuestos del material de espuma, según se ve en la dirección z, en el cual la parte de la espuma comprimida que ha sido humedecida mediante la solución de monómero se expande, y luego  
Polimerizar y reticular la solución de polímero, y  
Secar la estructura de espuma.

En la reivindicación 12 se define un artículo absorbente tal como una guarda de incontinencia, pañal, pañal pantalón, toalla sanitaria o similar de la clase que comprende una lámina superior permeable a los líquidos, una lámina posterior impermeable a los líquidos y una estructura absorbente dispuesta entre ellos, **caracterizada porque esta contiene una estructura absorbente como se reivindicó en cualquiera de las reivindicaciones 1 a 11.**

- Se afirma que se conocen estructuras absorbentes que vistas en la dirección de grosor tienen una concentración gradualmente creciente de artículos superabsorbentes, en la cual una alta concentración de material superabsorbente se localiza en la porción de la estructura absorbente que durante el uso se ubica más cercana a la lámina posterior impermeable a los líquidos. Al utilizar tal estructura se logra el riesgo de bloqueo de gel y una distribución de líquido mejorada. Un problema con tal estructura es que desde el punto de vista de la procesabilidad es difícil aplicar los artículos superabsorbentes de tal forma que una concentración de partícula gradualmente creciente se logra en la dirección de grosor de la estructura.

De igual manera se afirma que se pretende solucionar el problema de proporcionar un artículo absorbente que sea confortable y discreto de portar, a la vez que tenga una alta capacidad de adquisición de líquido y una alta capacidad de distribución de líquido.

- El objeto de la invención definido se catalogó como A61F 13/15, según la Clasificación Internacional de Patentes (IPC).

### 3. Claridad de la solicitud

El artículo 30 de la Decisión 486 de la Comisión de la Comunidad Andina establece que: "Las reivindicaciones definirán la materia que se desea proteger mediante la patente. Deben ser claras y concisas y estar enteramente sustentadas por la descripción.

Las reivindicaciones podrán ser independientes o dependientes. Una reivindicación será independiente cuando defina la materia que se desea proteger sin referencia a otra reivindicación anterior. Una reivindicación será dependiente cuando defina la materia que se desea proteger refiriéndose a una reivindicación anterior. Una reivindicación que se refiera a dos o más reivindicaciones anteriores se considerará una reivindicación dependiente múltiple".

- En la reivindicación independiente 1 se menciona que *'la porción de almacenamiento de líquido también contiene un material superabsorbente, en la cual la cantidad de material superabsorbente es inferior en la parte de la porción de almacenamiento de líquido que se encuentra lejos de la porción de adquisición de líquido que en la parte de la porción de líquido que se encuentra localizada más cercana a la porción de adquisición de líquido'*, mientras que en la reivindicación dependiente 2 se menciona que la *'cantidad de material superabsorbente en la dirección z de la porción de almacenamiento de líquido se incrementa gradualmente desde la parte de porción de almacenamiento de líquido que se localiza más cerca de la porción de adquisición de líquido hasta la parte de la porción de almacenamiento de líquido que se localiza más alejada de la porción de adquisición de líquido'* (Negrita Personal).

Con la información contenida en la reivindicación 1 se entiende que la parte de la capa de almacenamiento que se encuentra más cercana a la porción de adquisición de líquido es la que tiene mayor cantidad de material superabsorbente. De manera contraria, en la reivindicación 2 se entiende que la parte de la capa de almacenamiento que se encuentra más cercana a la porción de adquisición de líquido es la que tiene menor cantidad de material superabsorbente. Además en el folio 7 de la descripción en estudio se explica que: *"En la porción de almacenamiento de líquido que está localizada más cercana a la porción de adquisición de líquido la cantidad de material superabsorbente es inferior que en la porción de la porción de almacenamiento de líquido que está localizada más alejada de la porción de adquisición de líquido"*.

Dado lo anterior, la información contenida en la reivindicación 2 parece contradictoria respecto a la información de la reivindicación 1 y en la descripción. De todas maneras, se podría entender que la concentración de superabsorbente a lo largo de la dirección z es indiferente porque podría ser de diversas formas, es decir, mayor o menor cerca de la zona de adquisición de fluidos. Debido a lo anterior, se recomienda revisar las características diferenciadoras de la reivindicación independiente 1 de modo que se analice si la concentración de material superabsorbente es una variable indispensable en la invención propuesta y si es así, entonces eliminar la contradicción entre la reivindicación 1 y la reivindicación 2. Ahora bien, si la variable no es relevante se recomienda armonizar la información de las reivindicaciones citadas y particularmente incluir características diferenciadoras en la reivindicación independiente que sean coherentes y estén sustentadas en la descripción.

- En conclusión, las reivindicaciones 1 y 2 no cumplirían con el requisito de claridad de acuerdo con el art. 30 de la Decisión 486. Por lo tanto, se recomienda realizar las modificaciones pertinentes según las observaciones incluidas y allegar un nuevo capítulo reivindicatorio con tales modificaciones.

#### 4. Reivindicaciones de uso

El artículo 14 de la Decisión 486 de la Comisión de la Comunidad Andina establece: "Los Países Miembros otorgarán patentes para las invenciones, sean de producto o procedimiento, en todos los campos de la tecnología, siempre que sean nuevas, tengan nivel inventivo y sean susceptibles de aplicación industrial."

- En la reivindicación 12 se plantea un artículo absorbente caracterizado únicamente por que *'contiene una estructura absorbente como se reivindicó en cualquiera de las reivindicaciones 1 a 11'*.

Si bien el preámbulo tiene que ver con un producto, la parte caracterizante solo menciona que dicho artículo absorbente 'contiene una estructura absorbente' como la anteriormente definida. Esta forma de redacción da a entender que se espera reclamar la aplicación o el uso de la estructura absorbente dentro de un artículo absorbente. No obstante, la legislación no contempla la posibilidad de proteger los usos.

- En conclusión, la reivindicación 12 no es patentable de acuerdo con el artículo 14 de la Decisión 486.

**5. Determinación del estado de la técnica**

El artículo 16 de la Decisión 486 de la Comisión establece: "El estado de la técnica comprenderá todo lo que haya sido accesible al público por una descripción escrita u oral, utilización, comercialización o cualquier otro medio antes de la fecha de presentación de la solicitud de patente o, en su caso, de la prioridad reconocida.

Sólo para el efecto de la determinación de la novedad, también se considerará dentro del estado de la técnica, el contenido de una solicitud de patente en trámite ante la oficina nacional competente, cuya fecha de presentación o de prioridad fuese anterior a la fecha de presentación o de prioridad de la solicitud de patente que se estuviese examinando, siempre que dicho contenido esté incluido en la solicitud de fecha anterior cuando ella se publique o hubiese transcurrido el plazo previsto en el artículo 40."

- Se consultaron las bases de datos con que cuenta y tiene acceso la entidad y se consideró el 30 de agosto de 1999 como fecha para investigar el estado de la técnica.
- De acuerdo con lo establecido en el artículo 16 se determinó el estado de la técnica y se encontraron los siguientes antecedentes:

| No. | Documento No. | Título                         | Fecha de Publicación |
|-----|---------------|--------------------------------|----------------------|
| 1   | US5817704     | "HETEROGENEOUS FOAM MATERIALS" | 6 de octubre de 1998 |
| 2   | EP0478011     | "ABSORBENT ARTICLE"            | 19 de agosto de 1986 |
| 3   | US5338766     | "SUPERABSORBENT POLYMER FOAM"  | 16 de agosto de 1994 |

**6. Evaluación de los requisitos de patentabilidad**

El artículo 14 de la Decisión 486 de la Comisión de la Comunidad Andina establece: "Los Países Miembros otorgarán patentes para las invenciones, sean de producto o de procedimiento, en todos los campos de la tecnología, siempre que sean nuevas, tengan nivel inventivo y sean susceptibles de aplicación industrial."

En cumplimiento con este artículo, se procedió a evaluar los requisitos de novedad, nivel inventivo y aplicación industrial con el fin de establecer la patentabilidad de la invención reivindicada en la solicitud en estudio.

## **Evaluación del Nivel Inventivo:**

El art. 18 de la Decisión 486 de la Comisión de la Comunidad Andina establece: "Se considerará que una invención tiene nivel inventivo, si para una persona del oficio normalmente versada en la materia técnica correspondiente, esa invención no hubiese resultado obvia ni se hubiese derivado de manera evidente del estado de la técnica."

Respecto al estado de la técnica:

- En el documento **US5817704** (llamado D1 de aquí en adelante) se divulga una estructura de espuma polimérica de celdas abiertas interconectadas de naturaleza flexible, microporosa que tiene por lo menos dos regiones distintas de diferentes tipos de espumas esparcidas de modo que entregan una mezcla deseada de propiedades en una pieza simple de material. Las regiones de la espuma polimérica tienen diferente densidad, composición polimérica, propiedades de superficie y/o morfología microcelular. La invención además se relaciona con una espuma polimérica absorbente heterogénea que, en contacto con fluidos acuosos (en particular fluidos corporales como orina y sangre) pueden capturar, distribuir y almacenar esos fluidos.

En D1 se enseña que la estructura absorbente también se pueden elaborar de manera que los cambios en las propiedades se presenten de manera graduales a lo largo de la dirección z (espesor).

- En el documento **EP0478011** (llamado D2 de aquí en adelante) se divulga un artículo absorbente mejorado que incluye una capa de material absorbente. Partículas de material superabsorbente son distribuidas dentro de la capa de material absorbente y estas partículas son dispuestas para formar un gradiente continuo de concentración de superabsorbente por lo menos en una porción de espesor de la capa absorbente.

En D2 se enseña que en los artículos provistos con tales estructuras absorbentes, el superabsorbente que produce gel es adecuadamente aislado de la superficie del cuerpo de una persona que usa el artículo, mientras que el bloqueo de gel se reduce.

En las figuras representativas se pueden observar las modalidades de incorporación de gradientes de concentración del material superabsorbente al interior de las estructuras absorbentes. Una de ellas constituye el aumento de la concentración de superabsorbente a medida que se aleja de la capa de adquisición en dirección z.

- En el documento **US5338766** (llamado D3 de aquí en adelante) se divulga una espuma polimérica superabsorbente que tiene una morfología para proveer propiedades de absorción mejoradas. La espuma preferiblemente comprende un polímero superabsorbente formado desde un monómero insaturado sustancialmente soluble en agua que tienen grupos carboxil neutralizados y un agente de entrecruzamiento interno. El monómero y el agente de reticulación son expandidos en la presencia de un agente de soplado insoluble en agua y un solvente deseable y reacciona para formar la espuma.

En D3 se enseña que los polímeros hinchables higroscópicamente incorporados en la espuma comprimida y basada en celulosa se emplea para absorber agua más de 10 veces su propio peso. Tales polímeros son conocidos e incluidos, por ejemplo, productos de la hidrólisis de almidón injertado con acrilonitrilo, cuerpo entrecruzado de poliácido, alcohol polivinílico, copolímero en bloque del ácido acrílico (acrilato), cuerpo entrecruzado de carboximetilcelulosa, y alcohol polivinílico desnaturalizado.

El polímero hinchable higroscópicamente puede ser usado en varias formas tales como gránulos, polvos y fibras, etc. Además, los polímeros hinchables pueden ser combinados con el material de absorción en numerosas formas, incluyendo por ejemplo, por dispersión en la espuma, por interposición entre hojas, por impregnación de la esponja con un monómero de polímero hinchable higroscópicamente y entonces permitirle ser incorporado en la espuma subsiguiente a la polimerización y reacciones de entrecruzado que tienen lugar en ese estado.

Respecto a la solicitud en estudio:

- El técnico de nivel medio versado en la materia encargado de resolver el problema puede ser un ingeniero químico que labore en la industria de artículos absorbentes y que atienda a planes de mejoramiento continuo normalmente definidos en las empresas.
- De acuerdo con la reivindicación independiente 1 de la solicitud en estudio, se propone una estructura porosa absorbente en un artículo absorbente caracterizada esencialmente por dos particularidades. Una es que la porción de adquisición de líquido y la porción de almacenamiento de líquido forman una unidad integrada, en la cual la porción de almacenamiento de líquido comprende una espuma de célula abierta polimérica igual o diferente de la espuma en la porción de adquisición de líquido.

Otra característica es que la porción de almacenamiento de líquido también contiene un material superabsorbente, en la cual la cantidad de material superabsorbente es inferior en la parte de la porción de almacenamiento de líquido que se encuentra lejos de la porción de adquisición de líquido que en la parte de la porción de almacenamiento de líquido que se encuentra localizada más cercana a la porción de adquisición de líquido.

Con relación a la primera característica, es necesario resaltar que D1 ya contienen enseñanzas sobre estructuras de espuma polimérica de celdas abiertas interconectadas, que presentan una sola unidad integrada con porciones que cumplen las funciones de captura, distribución y almacenamiento de fluidos corporales (D1; Resumen). Además de esto, con relación a la segunda característica, D2 ya contiene enseñanzas sobre la incorporación de material superabsorbente distribuido dentro de la capa de almacenamiento de modo que se dispone para formar un gradiente de continuo de concentración del superabsorbente a lo largo de la dirección z (o espesor) de la estructura, para subsanar los problemas de bloqueo de gel.

Ahora bien, si un técnico de nivel medio versado en la materia tuviera a su disposición las enseñanzas contenidas en D1 y D2 se vería impulsado a desarrollar estructuras absorbentes de espuma polimérica de celda abierta que cumple las funciones de adquirir, distribuir y almacenar fluidos, y podría ensayar la adición convencional de material superabsorbente de modo que se presente un gradiente de concentración a través de todo el espesor, teniendo en cuenta que esto reduce los problemas de bloqueo de gel como se menciona en D2.

Dado el análisis anterior, un técnico de nivel medio versado en la materia podría combinar las enseñanzas de D1 y D2 para desarrollar estructuras equivalentes a las de la solicitud y resolver el problema planteado. Así, proponer una estructura porosa absorbente con las características definidas en la reivindicación independiente 1 no representaría un efecto sorprendente que evidencie un salto tecnológico sobre lo conocido en el arte previo.

De acuerdo con la reivindicación independiente 11 de la solicitud en estudio, se propone un método de producción de una estructura fibrosa porosa absorbente, cuyo método se caracteriza por formar un material de espuma comprimido y secado, aplicar una solución de monómero de material superabsorbente a uno de los lados opuestos del material de espuma, polimerizar y reticular la solución de polímero y secar la estructura de espuma. No obstante, en el documento D3 se enseña que los polímeros hinchables pueden ser combinados con el material de absorción en numerosas formas, incluyendo por ejemplo, por dispersión en la espuma, por interposición entre hojas, por **impregnación de la esponja con un monómero de polímero hinchable higroscópicamente y entonces permitirle ser incorporado en la espuma subsiguiente a la polimerización y reacciones de reticulación que tienen lugar en ese estado** (D3; página 3, líneas 29 – 40). Dado lo anterior, un técnico de nivel medio versado en la materia que tuviera acceso a D1 y D3 o D2 y D3 podría verse motivado a desarrollar un método de producción equivalente al de la solicitud, de modo que la propuesta del método tampoco parece representar un salto tecnológico respecto a lo conocido en el arte previo.

- Por lo anteriormente expuesto, la invención definida por las reivindicaciones 1 a 11 de la solicitud, podría verse afectado en su nivel inventivo ya que se deriva de manera evidente del estado de la técnica y puede ser obvia para un técnico de nivel medio versado en la materia. Por tanto, no cumpliría con las disposiciones del artículo 18 de la Decisión 486 de la Comisión de la Comunidad Andina.
- En conclusión, los requisitos de patentabilidad de la presente solicitud se encuentran afectados así:

| No. | Documento                                | Reivindicaciones Afectadas | Requisito que afecta |
|-----|------------------------------------------|----------------------------|----------------------|
| 1.  | US5817704                                | 1 – 10                     | Nivel Inventivo      |
| 2.  | EP0478011                                |                            |                      |
| 3.  | US5338766 en combinación con D1 o con D2 | 1 – 10<br>11               | Nivel Inventivo      |

Se anexan los apartes principales de las anterioridades en el documento adjunto.

En cumplimiento del artículo 45 de la Decisión 486 de la Comisión de la Comunidad Andina, se le indica que debe dar respuesta dentro del término de sesenta días contados a partir de la fecha de notificación de la presente comunicación. En caso de no dar respuesta al presente requerimiento, o si a pesar de la respuesta subsistieran los impedimentos para la concesión, se denegará la patente.

Notifíquese el presente oficio conforme a lo dispuesto en el numeral 5.2, literal e), del capítulo quinto del título primero de la circular única No. 10 de 2001.

**ALIX CARMENZA CESPEDES DE VERGEL**  
Jefe de División de Nuevas Creaciones

El anterior requerimiento fue notificado por fijación en lista, de fecha

**14 JUL 2001**

|                                    |                                                |
|------------------------------------|------------------------------------------------|
| <b>CONCEPTO</b><br>TECNICO No. 982 | <b>EXAMINADOR TECNICO</b><br>Código No. 202042 |
|------------------------------------|------------------------------------------------|



US005817704A

# United States Patent [19]

Shiveley et al.

[11] Patent Number: 5,817,704  
[45] Date of Patent: Oct. 6, 1998

## [54] HETEROGENEOUS FOAM MATERIALS

[75] Inventors: Thomas Michael Shiveley, Moscow;  
Thomas Allen DeaMarais; John  
Collins Dyer, both of Cincinnati; Keith  
Joseph Stone, Fairfield, all of Ohio

[73] Assignee: The Procter & Gamble Company,  
Cincinnati, Ohio

[21] Appl. No.: 612,643

[22] Filed: Mar. 8, 1996

[51] Int. Cl.<sup>8</sup> ..... C08J 9/28

[52] U.S. CL ..... 521/63; 521/64

[58] Field of Search ..... 521/64, 63

## [56] References Cited

## U.S. PATENT DOCUMENTS

|           |         |                      |           |
|-----------|---------|----------------------|-----------|
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| 3,256,219 | 6/1966  | Will                 | 260/25    |
| 3,431,911 | 3/1969  | Michel, Jr.          | 128/287   |
| 3,565,817 | 2/1971  | Lissant              | 252/312   |
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## [57] ABSTRACT

The present invention relates to a HIPE-derived heterogeneous polymeric foam structure of interconnected open-cells, wherein the foam structure has at least two distinct regions. Such heterogeneous foams have various applications, such as energy and fluid absorption, insulation, and filtration.

The invention further relates to a heterogeneous absorbent polymeric foam that, upon contact with aqueous fluids (in particular body fluids such as urine and blood), can acquire, distribute, and store these fluids.

The foams of the invention have at least two distinct regions having different density, polymer composition, surface properties, and/or microcellular morphology.

The invention further relates to a process for obtaining the heterogeneous foams by polymerizing a high internal phase water-in-oil emulsion, or HIPE. In one aspect, the process utilizes at least two distinct HIPEs, with each emulsion having a relatively small amount of an oil phase and a relatively greater amount of a water phase.

34 Claims, 13 Drawing Sheets

## HETEROGENEOUS FOAM MATERIALS

## FIELD OF THE INVENTION

This application relates to flexible, microporous, open-celled polymeric foam materials having two or more distinct regions of different types of foam interspersed so as to deliver a desired mixture of properties in a single piece of material.

## BACKGROUND OF THE INVENTION

Flexible open-celled polymeric foams are widely used for energy absorption or insulation (thermal, acoustic, mechanical), filtration, absorption of fluids, and the like. In most cases, the foams desired for these purposes have relatively homogeneous structures comprising cells within a given size range joined by open "windows" or "holes" to adjacent cells. Among the various measures of such foams that are important for each application are cell size/hole size and distribution, anisotropy, proportion of cell struts to windows, and porosity. Anisotropy can arise from the relative deviation between the shape of all the cells in the foam and some geometric ideal. In general, work has been devoted to making foams as homogeneous and isotropic as possible with respect to cell size and shape and density.

Polyurethane foams having a range of densities are known materials. For example, the "integral skin" flexible polyurethane foams have high density skin layers that transition gradually over 1-3 cm into a lower density core region. See for example Ashida, K.; Iwasaki, K. In *Handbook of Plastic Foams*, Landrock, A. H., ED.; Noyes, 1995; Chapter 2, pp 56, 64-67, incorporated herein by reference. The overall densities of such foams are typically between about 200 and 1,100 kg/m<sup>3</sup>. These foams do not exhibit distinct regions having different compositional or microstructural properties within a single piece. Typically, these foams also have higher densities, larger cell sizes and/or larger hole sizes than foams which may be preferred for certain applications.

Foams may be made from polymer networks which have been entangled to form an interpenetrating network (IPN). IPNs may exhibit some of the properties of both polymer types. See for example Odian, G. G. "Principles of Polymerization", 3rd edition, Wiley-Interscience: New York, 1991, New York, pp 149-150. IPNs do not inherently relate to control over any features at a supramolecular scale (e.g., density or cell size).

Laminates or sandwiches of two or more layers of foams having differing properties are also well known. See for example Gibson, L. J.; Ashby, M. F. "Cellular Solids" Pergamon Press: Oxford, 1988, Chapter 9. Formation of such composites requires an additional step and may require use of adhesive which may interfere with the functioning or weight of the foam composite and serves as a potential point of failure.

The development of highly absorbent articles for use as disposable diapers, adult incontinence pads and briefs, and sanitary napkins, is the subject of substantial commercial interest. The ability of such products to acquire, distribute, and store fluids such as are found in body exudates (e.g., urine, sweat, feces, and menses) is obviously critical to their function. Historically, this has been primarily achieved by using a combination of cellulosic fibers and interpermeated superabsorbent particles (generally lightly crosslinked partially neutralized polyacrylic acid that forms a gel when exposed to free water). This approach has, however, encountered a number of difficulties in achieving efficient removal of fluid from the body of the wearer and storage away from

the wearer, in part due to the difficulty in controlling and maintaining the appropriate blend of particulate and fiber to provide the desired degree of capillary fluid transport and cure integrity and flexibility.

Other absorbent materials capable of providing capillary fluid transport include certain types of polymeric foams in absorbent articles for the purpose of imbibing, wicking and/or retaining aqueous body fluids. See, for example, U.S. Pat. No. 3,563,243 (Lindquist), issued Feb. 6, 1971 (absorbent pad for diapers and the like where the primary absorbent is a hydrophilic polyurethane foam sheet); U.S. Pat. No. 4,554,297 (Dabi), issued Nov. 19, 1985 (body fluid absorbing cellular polymers that can be used in diapers or catamenial products); U.S. Pat. No. 4,740,520 (Garvey et al), issued Apr. 26, 1988 (absorbent composite structure such as diapers, feminine care products and the like that contain sponge absorbents made from certain types of super-wicking, crosslinked polyurethane foams). These foams can provide core integrity and flexibility but not the desired degree of capillary fluid transport.

The use of appropriate absorbent foams in absorbent articles such as diapers and catamenial pads can provide features of capillary fluid acquisition, transport and storage required for use in high performance absorbent cores. Absorbent articles containing such foams can possess desirable wet integrity, can provide suitable fit throughout the entire period the article is worn, and can minimize changes in shape during use (e.g., swelling, bunching).

Particularly suitable absorbent low density open-celled foams have been made from High Internal Phase Emulsions (hereafter referred to as "HIPEs"). See, for example, U.S. Pat. No. 5,260,345 (DesMarais et al), issued Nov. 9, 1993; and U.S. Pat. No. 5,260,224 (DesMarais et al), issued Dec. 7, 1993. Other suitable absorbent foams are described in co-pending applications U.S. Ser. No. 08/370,922 (DesMarais et al, filed Jan. 10, 1995); U.S. Ser. No. 08/370,695 (Stone et al., filed Jan. 10, 1995); U.S. Ser. No. 08/370,697 (Dyer, filed Jan. 10, 1995); and U.S. Ser. No. 08/520,793 (DesMarais, filed Aug. 30, 1995), all incorporated by reference herein. The HIPE process provides facile control over the cell and hole size and distribution, proportion of cell struts to windows, and porosity in these foams. When suitably treated to render the surface of these foams hydrophilic, these HIPE foams provide desirable fluid handling properties, including: (a) relatively good wicking and fluid distribution characteristics to transport the imbibed urine or other body fluid away from the initial impingement zone and into the unused balance of the foam structure to allow for subsequent gushes of fluid to be accommodated; and (b) a relatively high storage capacity with a relatively high fluid capacity under load, i.e., under compressive forces. These HIPE absorbent foams are also sufficiently flexible and soft so as to provide a high degree of comfort to the wearer of the absorbent article, and can be made relatively thin until subsequently wetted by the absorbed body fluid.

An important issue associated with the fluid handling properties of an absorbent foam is capillary structure. Foams having larger cell sizes and hole sizes tend to acquire fluid quickly but do not distribute fluid sufficiently against the force of gravity, nor do they store fluid effectively. Conversely, foams having smaller cell sizes and hole sizes are able to wick fluid against the force of gravity and store the fluid tightly to keep it away from the skin of the wearer, but are typically slower to acquire fluid. As indicated, heretofore, these opposing functions in an absorbent article have been achieved primarily by layering, in the z-direction,

different types of distinct absorbent foams which provide different functions. This adds complexity and cost to the process and can limit the product designs desired to those which allow for combination of individual pieces. Also, these designs are limited in being able to move fluids by differential capillary pressure only between the layers in the "z-dimension" of the articles, i.e., not in the "x-y dimension" or within the plane of a given layer.

Another important issue is the strength or resistance to compression deflection of the foam. Foams having comparatively higher densities, higher Tgs (defined hereinafter), and/or higher crosslinker levels generally exhibit greater resistance to deforming under pressure. This is achieved at the expense of using more polymer per unit volume, having a foam which deforms too slowly for practical use, or a foam which is too brittle or inflexible.

Accordingly, it would be desirable to be able to make an open-celled polymeric foam material that combines the various properties listed above as distinct regions within one material that: (1) expresses a combination of cell sizes and/or hole sizes in different distinct regions of a single piece of foam, and/or (2) expresses a combination of strengths and flexibilities in a single piece of foam, and/or (3) expresses a combination of energy absorbent properties in a single piece of foam. This can circumvent, at least partially, the need to use separate pieces of foams to serve different purposes, thereby enhancing the efficiency and simplicity of articles made with the objects of the current invention.

#### SUMMARY OF THE INVENTION

The present invention relates to a HIPE-derived heterogeneous polymeric foam structure of interconnected open-cells, wherein the foam structure has at least two distinct regions. Such heterogeneous foams have various applications, such as energy and fluid absorption, insulation, and filtration.

The invention further relates to a heterogeneous absorbent polymeric foam that, upon contact with aqueous fluids (in particular body fluids such as urine and blood), can acquire, distribute, and store these fluids. Preferably, the heterogeneous absorbent polymeric foam of the present invention comprises a hydrophilic, flexible, nonionic polymeric foam structure of interconnected open-cells.

Regardless of whether the heterogeneous foam of the present invention is relatively hydrophobic, or is a hydrophilic foam suitable for aqueous fluid absorption, the foam has at least two distinct regions that differ with regard to one or more of foam density, polymer composition, specific surface area, or microcellular morphology (e.g., cell size, shape, or distribution, or hole size).

The present invention further relates to a process for obtaining the heterogeneous foams by polymerizing a water-in-oil emulsions or HIPE. In one aspect, the process utilizes at least two distinct HIPEs, with each emulsion having a relatively small amount of an oil phase and a relatively greater amount of a water phase. This process comprises the steps of:

A) forming a first water-in-oil emulsion from:

1) an oil phase comprising:

a) from about 85 to about 98% by weight of a monomer component capable of forming a copolymer having a Tg of about 95° C. or lower, the monomer component comprising:

i) from about 20 to about 70% by weight of at least one substantially water-insoluble mono-

functional monomer capable of forming an atactic amorphous polymer having a Tg of about 25° C. or lower;

ii) from about 10 to about 50% by weight of at least one substantially water-insoluble monofunctional comonomer capable of imparting toughness about equivalent to that provided by styrene;

iii) from about 5 to about 50% by weight of a first substantially water-insoluble, polyfunctional crosslinking agent selected from divinylbenzenes, trivinylbenzenes, divinyltoluenes, divinylxylenes, divinylphthalenes, divinylalkylbenzenes, divinylphenanthrenes, divinylbiphenyls, divinylidiphenylmethanes, divinylbenzyls, divinylphenylethers, divinylidiphenylsulfides, divinylfurans, divinylsulfide, divinylsulfone, and mixtures thereof; and

iv) from 0 to about 15% by weight of a second substantially water-insoluble, polyfunctional crosslinking agent selected from polyfunctional acrylates, methacrylates, acrylamides, methacrylamides, and mixtures thereof; and

b) from about 2 to about 15% by weight of an emulsifier component which is soluble in the oil phase and which is capable of forming a stable water-in-oil emulsion, the emulsifier component comprising a primary emulsifier having at least about 40% by weight emulsifying components selected from diglycerol monoesters of branched C<sub>16</sub>-C<sub>24</sub> fatty acids, linear unsaturated C<sub>16</sub>-C<sub>22</sub> fatty acids, and linear saturated C<sub>12</sub>-C<sub>14</sub> fatty acids; sorbitan monoesters of branched C<sub>16</sub>-C<sub>24</sub> fatty acids, linear unsaturated C<sub>16</sub>-C<sub>22</sub> fatty acids, linear saturated C<sub>12</sub>-C<sub>14</sub> fatty acids; diglycerol monoaliphatic ethers of branched C<sub>16</sub>-C<sub>24</sub> alcohols, linear unsaturated C<sub>16</sub>-C<sub>22</sub> alcohols, and linear saturated C<sub>12</sub>-C<sub>14</sub> alcohols, and mixtures thereof; and

2) a water phase comprising an aqueous solution containing: (a) from about 0.2 to about 20% by weight of a water-soluble electrolyte; and (b) an effective amount of a polymerization initiator;

3) a volume to weight ratio of water phase to oil phase in the range of from about 20:1 to about 200:1;

B) optionally forming a second, distinct water-in-oil emulsion which is different in at least one respect from the first emulsion, but which comprises materials and ranges selected from those listed in parts A)1), A)2), and A)3); and

C) either

1) a) combining the first and second water-in-oil emulsions in a forming vessel prior to polymerizing the monomer components of either of the water-in-oil emulsions; and

b) polymerizing both emulsions to form a polymeric, heterogeneous foam;

2) a) partially or completely polymerizing the monomer components in the oil phase of the first water-in-oil emulsion;

b) combining the material from step C)2)a) and the second water-in-oil emulsion; and

c) polymerizing the second emulsion, and the first emulsion if combined when partly cured, to provide a polymeric, heterogeneous foam; or

3) making only the first water-in-oil emulsion while varying the process conditions by which it is

formed in a regular fashion using a single emulsion forming head as described hereinafter.

In one embodiment, one of the emulsions generated may be poured into a container or reservoir partially or completely filled with spherical segments or strips of material prepared from a previously polymerized, second emulsion. These spherical segments or strips of material are thoroughly saturated with an aqueous solution closely approximating the composition of the aqueous phase used to form the emulsion added. This mixture is then cured at an appropriate temperature to make a heterogeneous foam of the present invention.

In another embodiment, striped segments of unlike material may be prepared using two or more emulsion forming nozzles expressing different emulsions, layer upon layer, in a forming vessel; or by rhythmically varying the emulsion-making conditions with the single emulsion nozzle. In this case, control over the relative rates of pouring and the relative dispositions of the two nozzles provides control over the spatial relationships of the two (or more) different types of polymeric material developed in the final cured foam.

In a third embodiment, a single emulsion is produced, but one or more of the conditions of shear, water-to-oil ratio, pour temperature, and the like are rhythmically or continuously varied so as to produce regions in the resultant foam of different properties. Thus, unlike the two embodiments described above, formation of the optional second emulsion is not necessary in this embodiment.

In a fourth embodiment, a first unpolymerized emulsion is introduced into a form containing a second emulsion which is not substantially polymerized. By introducing the first emulsion from a nozzle positioned at the bottom of the form while withdrawing the nozzle, the emulsion forms a column or other geometric figure within the second emulsion. The process is repeated. Slices of the cured emulsion thus possess regularly repeating cross sections of the first emulsion in the form of the geometric figure imbedded in the plane of the slice of the second emulsion. Thus, regions of differing properties are introduced within a sheet of material.

In a fifth embodiment, a first emulsion (uncured or cured) is molded or cut to a shape that acts as a mold or fits into a mold for an additional amount of a distinct emulsion, which provides irregular, non-planar cross sections of intimately contacted material in the final cured product.

In a sixth embodiment, a single emulsion is subjected to centrifugation prior to polymerization. Conditions of the centrifugation are mild enough that the water droplets are not ruptured to disrupt the emulsion, but stringent enough to form a density gradient within the emulsion. Upon curing, a density gradient will exist in the foam.

Of course, the skilled artisan will recognize that more than two distinct emulsions can be employed, so as to provide a heterogeneous foam comprising regions with more than two different properties.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 of the drawings is a photomicrograph (250x magnification) of the first region of a heterogeneous foam having four regions and three interfaces.

FIG. 2 of the drawings is a photomicrograph (250x magnification) of the second region within the same heterogeneous foam.

FIG. 3 of the drawings is a photomicrograph (250x magnification) of the second interface of the same heterogeneous foam, where individual pour lines intersect between the second and third regions.

FIG. 4 of the drawings is a photomicrograph (250x magnification) of the third region within the same heterogeneous foam.

FIG. 5 of the drawings is a photomicrograph (250x magnification) of the third interface of the same heterogeneous foam where individual pour lines intersect between the third and fourth regions.

FIG. 6 of the drawings is a photomicrograph (250x magnification) of the fourth region within the same heterogeneous foam.

FIG. 7 of the drawings is a photomicrograph (30x) of the first of the three interfaces within the same heterogeneous foam.

FIG. 8 of the drawings is a photomicrograph (30x) of the second of the three interfaces within the same heterogeneous foams.

FIG. 9 of the drawings is a photomicrograph (30x) of the third of the three interfaces within the same heterogeneous foams.

FIG. 10 is a top-plan view of a catamenial product having a heterogeneous foam of the present invention as an absorbent member.

FIG. 11 is a cutaway depiction of a disposable diaper that utilizes the absorbent polymeric foam of the present invention as an hourglass-shaped fluid storage/distribution component, optionally in an absorbent diaper core of dual-layer configuration.

FIG. 12 of the drawings represents a cut-away view of a form-fitting article such as a disposable training pants product that employs an absorbent polymeric foam according to the present invention as an absorbent core.

FIG. 13 of the drawings is a perspective view of a single piece of heterogeneous foam of the present invention having three distinct regions, where the middle region is a relatively large celled structure and the two outer regions are both relatively small celled structures. Alternatively, the distinct regions may differ with regard to capillary suction specific surface area per volume.

FIG. 14 of the drawings is a perspective view of a single piece of heterogeneous foam of the present invention having 5 distinct regions.

FIG. 15 of the drawings is a perspective view of the same foam structure as that depicted in FIG. 13, where the foam is c-folded so as to provide a structure having a relatively large celled structure on the top and a relatively small celled structure on the bottom. This foam structure is particularly suited for use as an absorbent article such as a catamenial pad, and provides both an acquisition/distribution layer and a storage layer in one piece of foam.

FIG. 16 is a perspective view of a single piece of heterogeneous foam having discontinuous spheres located within a discrete, continuous region.

FIG. 17 is a cross-sectional view of the side of a single piece of heterogeneous foam of the present invention having discrete regions in the z-direction (i.e., thickness) of the foam.

FIG. 18 is a perspective view of the same piece of heterogeneous foam shown in FIG. 17, again showing the discrete regions in the z-direction of the foam.

FIG. 19 is a photomicrograph (250x magnification) of a heterogeneous foam having discrete, unconnected regions dispersed in a continuous region. The photomicrograph is believed to be taken at the interface of the continuous and at least one dispersed region. Surprisingly, no discontinuity is observed between the regions.

#### DETAILED DESCRIPTION OF THE INVENTION

##### 1. Heterogeneous Polymeric Foam

The foams of this invention are heterogeneous, open-celled foams. The heterogeneity relates to distinct regions

within the same foam which are different in terms of any of the parameters of cell size, hole size, polymer composition, specific surface area or density. The distinct regions are on the macro scale, typically at least millimeter scale dimensions. The foams are preferably of relatively low density having aggregate densities less than about 50 kg/m<sup>3</sup> (0.050 g/cc). "Open celled" refers to foams wherein the majority of adjoining cells are in open communication with each other, defined more fully below. These foams are preferably prepared from HIPs, as described in more detail hereinafter.

The general utility of such heterogeneous foams is broad. For example, foams may be specifically formulated to absorb around a specific frequency of sound energy at a given temperature. Two frequencies may be absorbed by sandwiching two distinct, optimized layers of foam together, requiring an additional process step. The foams of the present invention may be constructed so as to comprise distinct regions optimized to absorb around two or more specific frequencies without the requirement of lamination of two dissimilar pieces of foam.

In filtration applications, the hole size and void volume of the foam governs the efficiency of particulate removal as well as the flow restriction applied to the filtered fluid. A heterogeneous foam of the present invention may be constructed with regions of small holed material interspersed amidst regions of larger holed material so as to filter fine particulates without obstructing the flow of the fluid through the filter. In a recirculating filtration system, the finer particles will eventually be trapped by the smaller holed regions of the heterogeneous foam.

Yet another similar concept applies to absorbent foams wherein a foam of a relatively larger cell size and hole size may more quickly absorb fluid in an absorbent article. Such foams are typically layered over absorbent foams having relatively smaller cell sizes and hole sizes which exert more capillary pressure and drain the acquired fluid from the upper layer, restoring its ability to acquire more fluid. The composite structures well known in the art are limited by the ability to join two separate layers of material, including foam, suitably and conveniently. The foams of the present invention may be so constructed as to provide the properties of two or more separate pieces of foam in one material without any intermediate joining step.

A preferred use of the foams of the present invention is as absorbent core materials in absorbent articles for use as disposable diapers, adult incontinence pads and briefs, and sanitary napkins.

The foam material of the present invention contains at least two regions that differ with regard to their chemical and/or physical make-up. As used herein, the terms "distinct regions" and "distinct foam regions" mean that the regions differ with regard to one or more of foam density, polymer composition, specific surface area, or microcellular morphology (e.g., cell size, hole size). The difference(s) between the discrete regions will be readily measurable. For example, if the difference(s) relates to microstructure, the mean cell diameter or the mean hole diameter in each region should differ by at least about 20%, preferably at least about 35%, more preferably at least about 50%. If the differences relate to density, the densities of the distinct regions should differ by at least about 20%, preferably at least about 35%, more preferably at least about 50%. For example, if one region has a density of 0.020 g/cc, a distinct region should have a density of at least about 0.024 g/cc or less than about 0.016 g/cc, preferably at least about 0.027 g/cc or less than about 0.013 g/cc, and most preferably at least about 0.030 g/cc or

less than about 0.010 g/cc. If the differences are compositional in nature, the differences should reflect a relative difference in at least one monomer component of at least about 20%, preferably 35%, more preferably at least about 50%. For example, if one region is composed of about 10% styrene in its formulation, a distinct region should be composed of at least about 12%, preferably at least about 15%, or no more than about 8%, preferably no more than about 5%. Where heterogeneity is based on differences in cell size, if one region contains cells having a mean diameter of about 100  $\mu$ m, a distinct region should contain cells having a mean diameter of less than about 80  $\mu$ m, preferably less than about 65  $\mu$ m, most preferably less than about 50  $\mu$ m. Where heterogeneity is based on differences in hole size, if one region contains holes having a mean hole diameter of about 20  $\mu$ m, a distinct region should contain cells having a mean hole diameter of less than about 16  $\mu$ m, preferably less than about 13  $\mu$ m, most preferably less than about 10  $\mu$ m. Often, the differences will be as exaggerated as possible, though this will not always be desirable. The differences in regions may comprise all three types of differences discussed above in the ranges indicated. Also, more than two different regions may exist wherein the differences between the three or more distinct regions encompass the same difference ranges discussed above.

Although the foams of the present invention require distinct regions so as to be heterogeneous, these foams may possess a continuum of properties between regions. That is, while in certain embodiments there will be a relatively abrupt change in properties when moving from one region to the next, other embodiments will have a more gradual change of properties between regions.

Where two or more emulsions are employed to provide a heterogeneous foam, the term "distinct emulsions" means that the emulsions will differ to such a degree that their polymerization provides a foam of the present invention, i.e., having the requisite discrete regions. The skilled artisan will recognize what aspects of the emulsions (e.g., monomer reactants, water-to-oil ratio) and/or the conditions for their processing (e.g., shear rates, pour temperature) can be altered to provide foams having the requisite distinct regions. Where a foam is produced using one emulsion, processing conditions will provide the desired differences between regions.

Since the foams of the present invention have, by definition, distinct regions having different properties, the properties of each region may best be measured by using a homogeneous foam prepared in the same way. Some measurement techniques require sample sizes and shapes that are incompatible with the need to distinguish the different properties of each region within the heterogeneous foam. Measurements made on the composite heterogeneous foams in general will reflect by definition a volume or surface area averaged property of the distinct regions unless the measurement is made at a scale smaller than the size of the distinct region itself.

#### A. General Foam Characteristics

The multi-region foams of the present invention may comprise a dispersed, unconnected region(s) and a continuous region. The dispersed, unconnected region(s) may be in the shape of irregular spherical segments, or larger irregular shapes embedded within a continuous region of dissimilar foam. Alternatively, the distinct regions may be alternating stripes or swirls continuous in only two dimensions. Generally, the foam will consist of a region of discontinuous separated material of like properties dispersed in a region of continuous material having a second set of properties.

The ratio of the volume and/or weight fractions of each region is obviously important, and is readily varied. Preferably, for foams having discontinuous segments, at least about 10% of the foam volume will be the discontinuous segments or the effect may be too small to be beneficial. No more than about 90% of the foam volume will be the discontinuous segments or the effect may dominate the collective properties of the composite foam. Preferably, between about 20% and 50% of the volume of the foam will comprise the discontinuous segment volumes. If the foam is comprised of two or more continuous regions, each having distinct chemical and/or physical properties, preferably between about 20% and 80% of the foam volume will comprise one type with the balance being the other type(s). There is in principle no limit to the number of different regions which may be interspersed to provide a given foam of the present invention.

There are several advantages in using heterogeneous foams. When irregular spherical region(s) are dispersed in a continuous region (as is depicted in FIG. 16), the spherical region(s) may consist of a strong, low density polymer which is resistant to compression but which is too brittle or too high in T<sub>g</sub> to use as a continuous sheet. A composite foam consisting of brittle or high T<sub>g</sub> region(s) interspersed in a continuous matrix of flexible, tough absorbent polymer will retain the desirable properties of the latter. This composite foam can be made at lower density than a corresponding homogeneous foam. The density of the entire foam will reflect the weighted averages of the densities of the different regions. Such a foam can derive strength from the rigid sections which will have less tendency to collapse under pressure. The continuous flexible section provides the flexibility of the entire foam which would be lacking in a foam consisting only of the rigid polymer. In an alternative embodiment, discrete, unconnected regions may be dispersed in two or more discrete continuous regions.

In addition to modifying the polymer properties of the regions (e.g., T<sub>g</sub>, density, brittleness), the microcellular structure can be varied as well. This is particularly useful in combining several types of fluid handling properties in one piece of absorbent foam. For example, a foam having different regions with relatively higher and lower fluid capillary pressure can be developed. This is particularly useful when the regions in the foam piece are continuously dispersed rather than as discontinuous regions. By this method, stripes of material with larger cell sizes and hole sizes are interspersed with stripes of smaller cell sizes and hole sizes. (See FIGS. 13 and 14.) (Of course, other properties, such as specific surface area per volume may also or alternatively define the differences between the regions.) The larger cell/hole size region will be well suited for fluid acquisition and wicking, and the smaller cell/hole size regions will be better suited for fluid distribution against the force of gravity and storage. These stripes can provide for faster wicking along a preferred direction in an absorbent article, thereby keeping fluid away from the edges of the article, which is particularly useful in catamenial products. In one embodiment, the heterogeneous foam may comprise one relatively large stripe of large celled, large holed polymer positioned between two smaller stripes of small celled, small holed foam. (See FIG. 13.) This three-region foam may then be C-folded to produce two layers (see FIG. 15), each having a distinct fluid capillary pressure, making the foam suitable for fluid movement within an absorbent article without using a multiplicity of unwind stands for the materials.

Alternatively, as depicted in FIGS. 17 and 18, foams of the present invention may be prepared such that the transi-

tion from one region to another occurs in the z-direction (i.e., through the thickness) of the foam.

Polymeric foams according to the present invention useful in absorbent articles and structures are those which are relatively open-celled. This means the individual cells of the foam are in complete, unobstructed communication with adjoining cells. The cells in such substantially open-celled foam structures have intercellular openings or "windows" (referred to herein as "holes") that are large enough to permit ready fluid transfer from one cell to the other within the foam structure.

These substantially open-celled foam structures will generally have a reticulated character with the individual cells being defined by a plurality of mutually connected, three dimensionally branched webs. The strands of polymeric material making up these branched webs can be referred to as "struts." For purposes of the present invention, a foam material is "open-celled" if at least 80% of the cells in the foam structure that are at least 1 μm in size are in fluid communication with at least one adjacent cell.

In addition to being open-celled, preferred polymeric foams are sufficiently hydrophilic to permit the foam to absorb aqueous fluids in the amounts specified hereafter. The internal surfaces of the foam structures are rendered hydrophilic by residual hydrophilizing surfactants and/or salts left in the foam structure after polymerization, or by selected post-polymerization foam treatment procedures, as described hereafter.

Preferred hydrophilic, absorbent foams of the present invention will have at least one region particularly suited for acquisition/distribution of body fluids, and at least one region particularly suited for storage of body fluids. Copending U.S. application Ser. Nos. 08/370,695, filed Jan. 10, 1995 by Stone et al. (Case 5544), and 08/520,793, filed Aug. 30, 1995 by DesMarais (Case 5807), describe foam properties particularly suitable for fluid acquisition/distribution. Copending U.S. application Ser. No. 08/563,866, filed Nov. 29, 1995 by DesMarais et al. (Case 5541C) describes foams properties particularly suitable for fluid storage. The disclosures of each of these applications is incorporated by reference herein. The skilled artisan will recognize that the properties described in these copending applications can readily be provided in regions of the foams of the present invention, as desired. Moreover, preferred ranges for the various foam properties described in these copending applications are applicable to the curtain of the present hydrophilic foams.

The extent to which the preferred polymeric foams of the present invention are "hydrophilic" can be quantified by the "adhesion tension" value exhibited when in contact with an absorbable test liquid. The adhesion tension exhibited by these foams can be determined experimentally using a procedure where weight uptake of a test liquid, e.g., synthetic urine, is measured for a sample of known dimensions and capillary suction specific surface area. Such a procedure is described in greater detail in the TEST METHODS section of U.S. Pat. No. 5,387,207 (Dyer et al.) issued Feb. 7, 1995, which is incorporated by reference. Foams which are useful as absorbents in the present invention are generally those which exhibit an adhesion tension value of from about 15 to about 65 dynes/cm, more preferably from about 20 to about 65 dynes/cm, as determined by capillary absorption of synthetic urine having a surface tension of 65±5 dynes/cm. After compression, and/or thermal drying/vacuum dewatering to a practicable extent, these polymeric foams may have residual water that includes both the water of hydration associated with the hygroscopic, hydrated salt incorporated therein, as well as free water absorbed within the foam.

A Nonwoven and Apertured Film Coversheet" filed on Nov. 19, 1991 by Aziz, et al., which is incorporated by reference. Alternatively, the body surface of the topsheet can be made hydrophilic by treating it with a surfactant such as is described in the above referenced U.S. Pat. No. 4,950,254, incorporated herein by reference.

In use, pad 10 can be held in place by any support or attachment device (not shown) well-known for such purposes. Preferably, pad 10 is placed in the user's undergarment or panty and secured thereto by a fastener such as an adhesive. The adhesive provides a means for securing the pad in the crotch portion of the panty. Thus, a portion or all of the outer surface of the backsheet 18 is coated with adhesive. Any adhesive or glue used in the art for such purposes can be used for the adhesive herein, with pressure-sensitive adhesives being preferred. Before pad 10 is placed in use, the pressure-sensitive adhesive is typically covered with a removable release liner in order to keep the adhesive from drying out or adhering to a surface other than the crotch portion of the panty prior to use.

In another embodiment, an article containing a heterogeneous foam of the present invention is a disposable diaper. Disposable diapers comprising the absorbent foam structures of the present invention can be made by using conventional diaper making techniques, but by replacing or supplementing the wood pulp fiber web ("airfelt") or modified cellulosic core absorbents typically used in conventional diapers with one or more foam structures of the present invention. Foam structures of the present invention can thus be used in diapers in single layer, or in various multiple layer core configurations as previously described. A representative disposable diaper embodiment of the present invention is illustrated by FIG. 11 of the drawings. Such a diaper includes an absorbent core 20, comprising an optional upper fluid acquisition layer 21, and an underlying fluid storage/redistribution layer 22 comprising an absorbent heterogeneous foam structure of the present invention. A topsheet 23 is superposed and co-extensive with one face of the core, and a liquid impervious backsheet 24 is superposed and coextensive with the face of the core opposite the face covered by the topsheet. The backsheet most preferably has a width greater than that of the core thereby providing side marginal portions of the backsheet which extend beyond the core. The diaper is preferably constructed in an hourglass configuration.

Another type of absorbent article which can utilize the absorbent foam structures of the present invention comprises form-fitting products such as training pants. Such form-fitting articles will generally include a nonwoven, flexible substrate fashioned into a chassis in the form of briefs or shorts. An absorbent foam structure according to the present invention can then be affixed in the crotch area of such a chassis in order to serve as an absorbent "core". This absorbent core will frequently be over-wrapped with envelope tissue or other liquid pervious, nonwoven material. Such core overwrapping thus serves as the "topsheet" for the form-fitting absorbent article.

The flexible substrate which forms the chassis of the form-fitting article can comprise cloth or paper or other kinds of nonwoven substrate or formed films and can be elasticized or otherwise stretchable. Leg bands or waist bands of such training pants articles can be elasticized in conventional fashion to improve fit of the article. Such a substrate will generally be rendered relatively liquid-impervious, or at least not readily liquid-pervious, by treating or coating one surface thereof or by laminating this flexible substrate with another relatively liquid-impervious

substrate to thereby render the total chassis relatively liquid-impervious. In this instance, the chassis itself serves as the "backsheet" for the form-fitting article. Typical training pants products of this kind are described in U.S. Pat. No. 4,619,649 (Roberts), issued Oct. 28, 1986, which is incorporated by reference.

A typical form-fitting article in the form of a disposable training pants product is shown in FIG. 12 of the drawings. Such a product comprises an outer layer 30 affixed to a lining layer 31 by adhesion along the peripheral zones thereof. For example, the inner lining 31 can be affixed to the outer layer 30, along the periphery of one leg band area 32, along the periphery of the other leg band area 33, and along the periphery of waistband area 34. Affixed to the crotch area of the article is a generally rectangular absorbent core 35 comprising an absorbent heterogeneous foam structure of the present invention.

#### C. Composite Foams

As discussed above, numerous possibilities exist with regard to arrangement of the discrete regions within a given composite foam. The skilled artisan will recognize that in light of the teachings herein, routine experimentation will provide foams having various qualities, depending on the desired end-use. As such, though four representative foam embodiments are depicted and discussed in FIGS. 13, 14, 16, and 17/18, it is not intended that the scope of the invention is in any way limited to these embodiments.

Referring to FIG. 13, a heterogeneous foam 40 having repeating stripes is depicted. In particular, foam piece 40 has a region 46 of relatively large-celled material, positioned between two regions 42 and 44, both of relatively smaller celled material. Regions 42 and 44 may be either the same, or they may be different. As depicted rectangularly, foam piece 40 is suited for use as an absorbent core for a catamenial product. The relatively large celled region 46 will allow for rapid acquisition and distribution of discharged body fluid, while small celled regions 42 and 44 will prevent leakage at the sides of the product. Arcuate lines 47 and 48 depict optional cut-out regions that may be preferred where foam piece 40 is used as an absorbent core material in a diaper. Alternatively, or in addition, the acquisition/distribution region 46 may have a relatively lower specific area per volume than storage regions 42 and 44.

The foam depicted in FIG. 14 is similar to that shown in FIG. 13, but has five distinct regions instead of three. In a preferred embodiment, center region 54 will comprise relatively large celled material, which is suited for rapid acquisition of body fluid. Outer regions 52 and 56 will preferably comprise relatively small celled material, again to prevent leakage of fluid from the sides of the corresponding product. Regions 53 and 55 will both preferably comprise material that have cell sizes smaller than region 54, but larger than regions 52 and 56. As a core for a feminine hygiene pad, outer regions 52 and 56 may have hole sizes smaller than 8  $\mu$ m to preclude passage of red blood cells into the outer edges of the product which might signal impending side-leakage and failure to the consumer. Such regions will absorb free fluid from the menses without passing red blood cells and attendant color.

The foam depicted in FIGS. 17 and 18 is illustrative of an embodiment where the distinct regions are layered in the z-direction. FIG. 17 is a side view of foam 70 having upper region 72 and lower region 74. FIG. 18 is a perspective view, again showing upper region 72 and lower region 74. This type of foam is particularly suitable as an absorbent material, such as a diaper, wherein upper region 72 is an acquisition material, and lower region 74 is a storage material. A foam

having regions layered in the z-direction can be formed by pouring an emulsion to form region 74 in a mold, and simultaneously or sequentially adding a second emulsion to form region 72. In a preferred embodiment, region 72 will have a relatively lower specific surface area per volume than region 74, which will allow region 74 to drain fluid from region 72.

IV. Test Methods

Many of the test methods used require a larger sample of homogeneous material than may be present in the heterogeneous foams of the present invention. Measurement of the properties of the distinct regions must then be obtained by taking a sample of the distinct emulsion streams, curing them identically, and using them to determine the specific independent properties of the heterogeneous regions of the foam.

A. Dynamic Mechanical Analysis (DMA)

DMA is used to determine the Tgs of polymers including polymeric foams. Samples of the foams are sliced into blocks 3-5 mm in thickness and washed 3-4 times in distilled water, expressing the fluid through roller nips between each washing. The resulting foam blocks are allowed to dry in air. The dried foam slices are cored to yield a cylinder 25 mm in diameter. These cylinders are analyzed using a Rheometrics RSA-II dynamic mechanical analyzer set in compression mode using parallel plates 25 mm in diameter. Instrument parameters used were as follows:

Temperature step from ca. 85° C. to -40° C. in steps of 2.5° C.

Soak intervals between temperature changes of 125-160 seconds

Dynamic strain set at 0.1% to 1.0% (usually 0.7%)

Frequency set at 1.0 radians/second

Autotension set in static force tracking dynamic force mode with initial static force set at 5 g.

The glass transition temperature is taken as the maximum point of the loss tangent versus temperature curve. Tg is appropriately measured only on a homogeneous portion of the heterogeneous foam, or from a representative piece of homogeneous foam prepared under the same conditions as the region from the heterogeneous foam.

B. Resistance to Compression Deflection (RTCD)

Resistance to compression deflection can be quantified by measuring the amount of strain (% reduction in thickness) produced in a foam sample which has been saturated and expanded with synthetic urine, after a confining pressure of 0.74 psi (5.1 kPa) has been applied to the sample as described in the TEST METHODS section of U.S. Pat. No. 5,387,207 (Dyer et al.) issued Feb. 7, 1995. Resistance to Compression Deflection measurements are typically made on the same sample concurrently with the measurement of Free Absorbent Capacity and Expansion Factor as described below.

C. Free Absorbent Capacity

Free absorbent capacity can be quantified by measuring the amount of synthetic urine absorbed in a foam sample which has been saturated and expanded with synthetic urine. Free Absorbent Capacity measurements are typically made on the same sample concurrently with the measurement of Resistance to Compression Deflection and Expansion Factor as described in the TEST METHODS section of U.S. Pat. No. 5,387,207 (Dyer et al.) issued Feb. 7, 1995.

D. Interfacial tension (IFT) method (Spinning Drop)

Interfacial Tension (IFT) is measured at 50° C. by the spinning drop method described in U.S. Pat. No. 5,387,207 (Dyer et al.) issued Feb. 7, 1995, (herein incorporated by reference), except that: (1) the monomer mixture used in preparing the oil phase contains styrene, divinylbenzene (55% technical grade), 2-ethylhexylacrylate, and 1,4-butanediol dimethacrylate in a weight ratio of 14:14:60:12; (2) the concentration of emulsifier in the oil phase is varied by dilution from an upper concentration of generally about 5-10 weight % down to a concentration where the IFT increases to a value that is at least about 10 dyne/cm greater than the minimum IFT, or about 18 dyne/cm, whichever is less; (3) a smooth line drawn through a plot of IFT versus log emulsifier concentration is used to determine the minimum IFT; (4) the Critical Aggregation Concentration (CAC) is determined by extrapolating the low-concentration, generally linear portion of the IFT versus log concentration plot (i.e., the portion of the curve typically used to calculate surface area per molecule at the interface, see for example Rosen, M. J. "Surfactants and Interfacial Phenomena"; 2nd ed.; Wiley & Sons: New York, 1989; pp 64-69) to higher concentration; the emulsifier concentration on this extrapolated line corresponding to the minimum IFT is taken as the CAC. Generally, an upper emulsifier concentration of about 5-10 weight % is used. Desirably, the upper emulsifier concentration used is at least about twice (more desirably at least about three times) the CAC of the emulsifier. For emulsifiers having a solubility in the oil phase at ambient-temperature of less than 5 wt. %, the upper concentration limit can be reduced as long as this concentration is still at least about twice the CAC of the emulsifier at 50° C.

E. Capillary Absorption Pressures

A capillary absorption isotherm curve is generated using the Vertical Wicking Absorbent Capacity test described in the TEST METHODS section of U.S. Pat. No. 5,387,207 (Dyer et al.) issued Feb. 7, 1995, which is incorporated by reference, except at 31° C. rather than 37° C. The curve is a plot of the absorbent capacity of each segment as a function of wicked height, using the distance from the top of the water reservoir to the midpoint of each segment for the height h. The capillary absorption pressure is taken as the height of the foam that has an absorbent capacity one-half of the foam's free absorbent capacity.

V. Specific Examples

These examples illustrate the specific preparation of foams from HIPEs according to the present invention.

EXAMPLE 1

Preparation of a Heterogeneous Foam from Two HIPE Streams

HIPE Preparation:

An aqueous phase is prepared containing the ingredients shown in Table 1. Two organic phases are prepared using the ingredients shown in Tables 2 and 3.

TABLE 1

| Aqueous Phase Composition for HIPE <sub>1</sub> |         |       |
|-------------------------------------------------|---------|-------|
| Water                                           | 756 L   |       |
| Potassium Peroxide                              | 370 g   | 0.05% |
| Calcium Chloride                                | 7,640 g | 10.0% |

in the middle bounded on each side by a region of smaller cell sized material. (In practice, the smaller cell sized regions may be poured at such a rate as to make its thickness 6 cm so that pieces can be suitably cut from a wide sheet of such foam.) The continuous piece is taken up on a roll and delivered to the pad making operation where it is folded into a "C"-shape by bending the outer 3 cm segments under the center 3 cm segment. The foam is then cut into a 20 cm length and placed into a pad under a topsheet and on top of a backsheet with appropriate adhesive application so as to secure it within the construction. This provides for a layer having faster fluid acquisition on top of a layer having greater capillary pressure which can effectively drain fluid from the upper layer as described in copending U.S. application Ser. No. 08/542,497, filed Oct. 13, 1995 by Dyer et al (Case No. 5546R), which is incorporated by reference, but constructed from a sheet off a single roll.

EXAMPLE 8

Tampon Made with Heterogeneous Foam

A tampon is constructed from a foam that is prepared essentially as described in Example 3 having thicknesses of the distinct regions based on different cell sizes being approximately 3 cm. The conditions of each region are shown in Table 7 below.

TABLE 7

| Region | RPM | Pour Temperature (°C.) | Approx. Mean Cell Size (µm) | Width of Region (cm) |
|--------|-----|------------------------|-----------------------------|----------------------|
| 1      | 800 | 66°                    | 50                          | 3                    |
| 2      | 400 | 66°                    | 120                         | 3                    |

A continuous piece is sliced 1.5 cm thick and 6 cm width. The continuous piece is taken up on a roll and delivered to the tampon core making operation where it is shaped into a tube by curling Region 1 around Region 2. The foam is then cut into a 10 cm length and placed inside an outer fluid permeable topsheet with appropriate adhesive application so as to secure it within the construction. This provides for a layer having faster fluid acquisition outside of a layer having greater capillary pressure which can effectively drain fluid from the upper (outer) layer as described in copending U.S. application Ser. No. 08/542,497, filed Oct. 13, 1995 by Dyer et al (Case No. 5546R), but constructed from a single sheet off a single roll.

EXAMPLE 9

A Heterogeneous Foam For Use in Filtration

The foam of Example 4 is sliced to a thickness of 5 mm and washed in water to remove most of the residual salts and then dried. The continuous slices of foam are cut into pieces 10 cmx10 cm and reinforced with an outer cardboard outsert covering the outer 1 cm of the foam on both sides. This outsert protects the edges of the material. This piece is inserted into an air stream passing through a plenum. The coarser celled region entraps larger particulates and passes the air stream with relatively little restriction. The finer celled region entraps smaller particles though it will pass the air stream with greater restriction to its flow.

EXAMPLE 10

A Heterogeneous Foam for Use as Sound Insulation

The foam of Example 5 is sliced to a thickness of 5 mm and washed in water to remove most of the residual salts and

then dried. The continuous slices of foam are cut into pieces 20 cmx20 cm. The edges of these pieces may be reinforced if needed as described in Example 9. These pieces are then secured to a wall separating a noisy device from a living space. Because the particulate pieces embedded within this foam will somewhat selectively absorb one frequency and the continuous segment of this foam will somewhat selectively absorb another frequency, a broader frequency absorption profile will be obtained, similar to that which would be obtained from two laminated homogeneous foams made separately from these emulsions.

EXAMPLE 11

Forming a Heterogeneous Foam from Three HIPE Streams

Two HIPES streams are prepared as described in Example 1 from the oil phase described in Table 2. The oil is split into two streams, Stream A and Stream B, to be mixed separately into two HIPEs which are compositionally identical but which have different water droplet sizes. Stream A is mixed through a dynamic pin mixer operating at 400 rpm at 66° C. emulsion temperature at a water:oil ratio of 45:1 at 5 lbs/min. Stream B is mixed through a dynamic pin mixer operating at 1600 rpm and 66° C. emulsion temperature at a water:oil ratio of 60:1 at 10 lbs/min. Stream B is further divided equally into two streams. Rather than being delivered into a rotating tub as described in preceding examples, the three streams are delivered into a long rectangular bed with Stream A being delivered into the center of the sluice and Stream B being delivered into each outer third of the sluice. The rectangular bed is bed 45 cm wide and 30 cm deep on a moving web. The length of the bed is indefinite and can be a continuous loop. The portion of the bed filled with the HIPEs is moved gradually into an oven to maintain the temperature at 66° C. suitable for curing of the HIPEs into a polymer. This produces a billet of HIPE foam of indefinite length from which segments may be cut suitable for use in diapers or catamenials and the like.

In a preferred embodiment, hourglass-shaped diaper segments are sliced to appropriate thickness (e.g., 5 mm) and cut from the web along its width (the 45 cm dimension). These cut segments will have foam suited for rapid fluid acquisition in the crotch region of the diaper and foam suited for storage of the fluid in the back and front regions of the diaper. Fluid introduced into the crotch region will be pulled by capillary force into the front and back regions against the force of gravity.

What is claimed is:

1. A heterogeneous polymeric foam structure of interconnected open-cells obtained from at least one water-in-oil emulsion, wherein the foam structure has at least two distinct regions that differ by at least about 20% with regard to one or more of polymer density, polymer composition, surface properties, or microcellular morphology.
2. The heterogeneous foam of claim 1 wherein the foam has an aggregate density of less than about 0.05 g/cc.
3. The heterogeneous foam of claim 1 wherein the foam comprises a) a continuous region; and b) discrete, unconnected regions dispersed in the continuous region.
4. The heterogeneous foam of claim 4 wherein the aggregate volume of the discrete regions is from about 10% to about 80% of the foam's total volume.
5. The heterogeneous foam of claim 1 wherein the foam comprises at least two discrete, continuous regions.
6. The heterogeneous foam of claim 3 wherein each continuous region comprises from about 20% to about 80% of the foam's total volume.

0-64171



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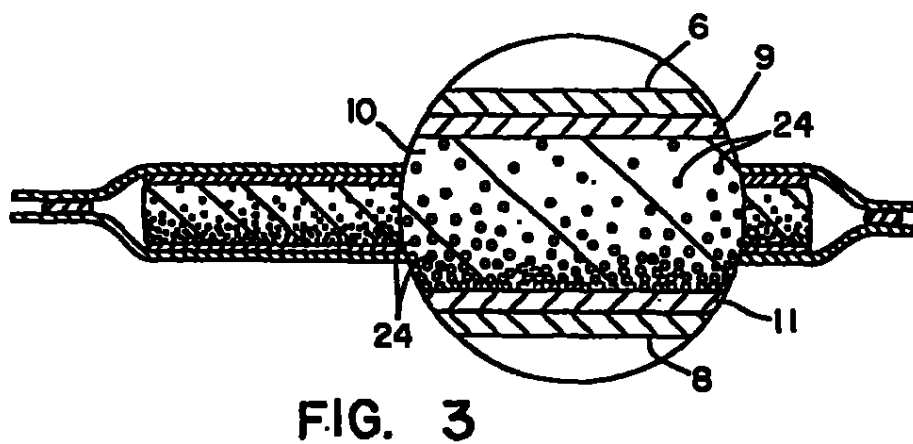
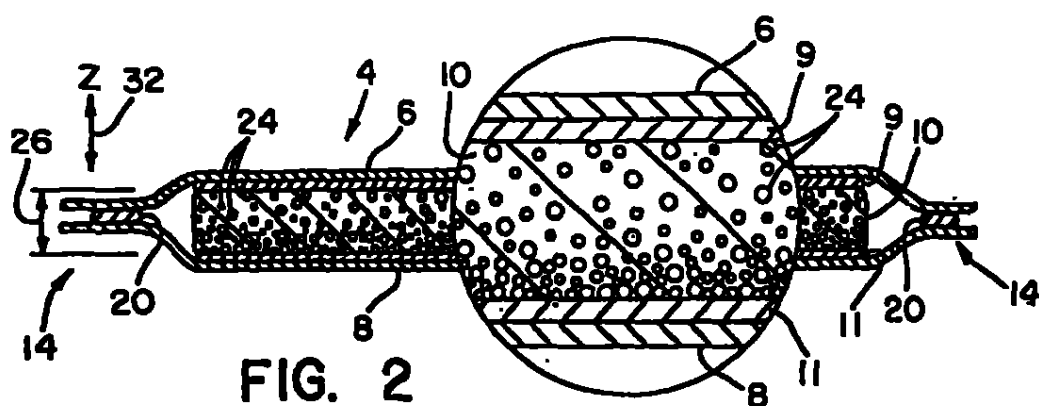
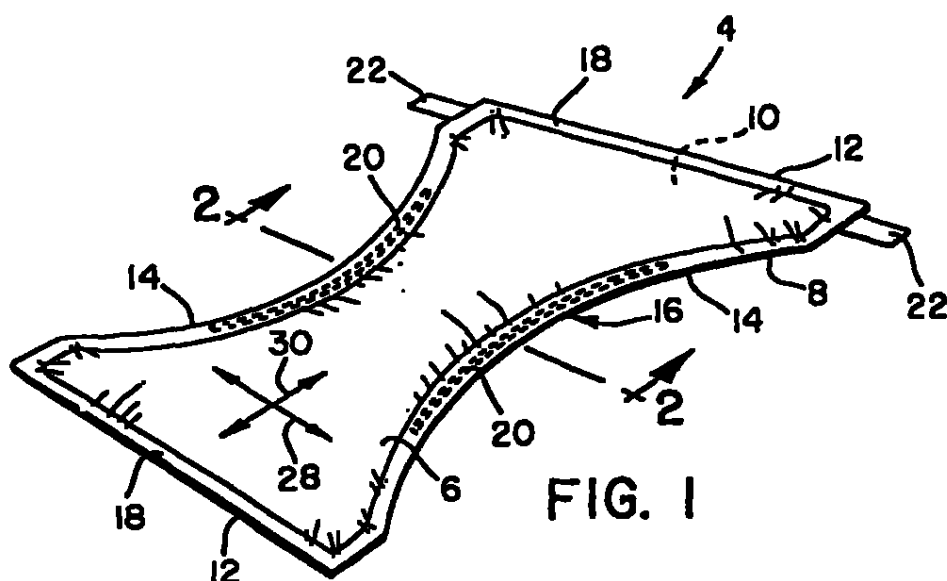
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⑳ Absorbent article.

㉑ An improved absorbent article includes a layer of absorbent material (10) which has a length, a width and a thickness (26). Particles of superabsorbent material (24) are distributed within the absorbent material layer, and these superabsorbent particles are disposed to form a substantially continuous, positive concentration gradient of superabsorbent through at least a portion of the thickness (26) of the absorbent layer. The superabsorbent particles (24) may be of the same dimension or the average particle size may vary throughout the thickness (26) of the layer of absorbent material. The article provides for absorbent structures wherein the superabsorbent produced gel is adequately isolated away from body surfaces of a person using the article while gel blocking is also adequately reduced.

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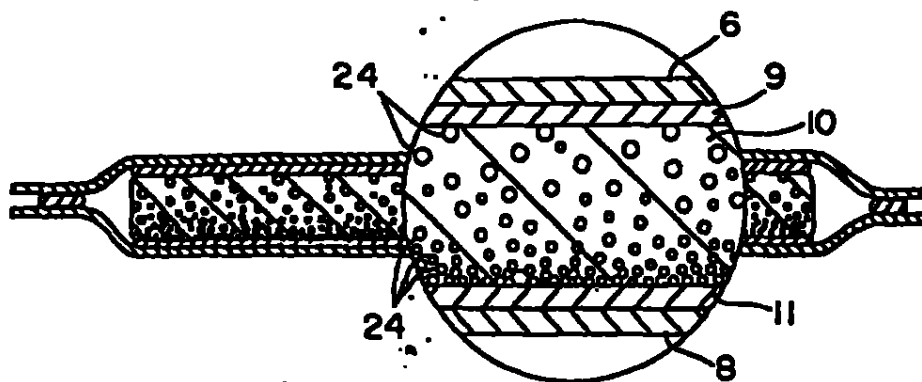


FIG. 4

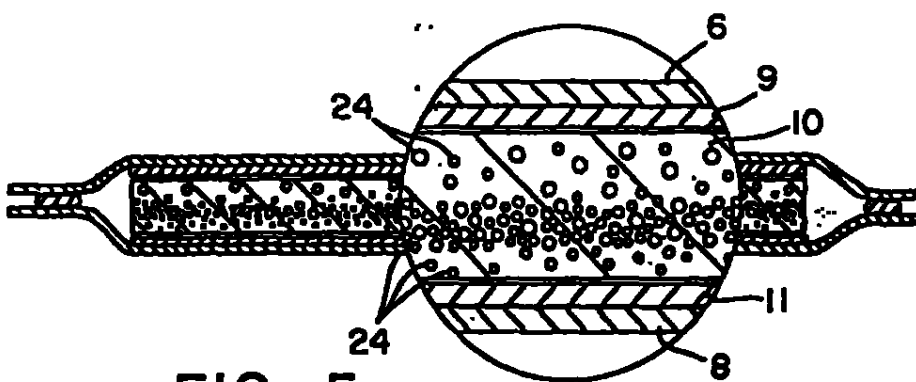


FIG. 5

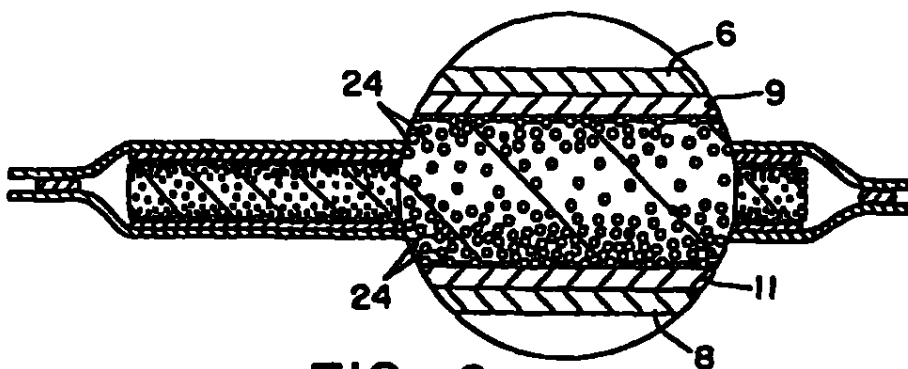


FIG. 6

The present invention is related to absorbent articles.

Disposable articles, such as diapers, sanitary napkins, incontinence garments, bandages and the like, employ pads or betts of absorbent material to absorb and retain liquids, such as body exudates. Significant effort has been devoted to increasing the amounts of liquids that can be retained by the absorbent pads. By increasing the absorbent capacity of the pads, the physical dimensions, such as the thickness, of the pads can advantageously be reduced.

Various types of absorbent pads have incorporated superabsorbent materials, such as superabsorbent polymers, to increase the liquid retention capacity of the pads. In certain configurations, the superabsorbent materials have been selectively located in particular discrete areas of the pad. For example, U.S. Patent 3,888,257 describes a disposable absorbent article which includes a matrix of fiberized wood pulp. Hydrocolloid polymer particles are located in a three-dimensional dispersion in a central zone or strip of the fiberized matrix. U.S. Patent 4,333,482 describes an absorbent structure which includes an absorbent batt, containing two reservoirs. The first reservoir opens toward the cover of the article, and the second reservoir is located below the first reservoir and contains particles of superabsorbent. U.S. Patent 4,381,783 describes an absorbent article which includes an absorbent layer having at least one discrete internal pocket. The pocket contains a uniform admixture of discrete superabsorbent particles and discrete introfying particles. U.S. Patent 4,381,782 discloses highly absorbent, low density fibrous structures, such as webs or betts which include mixtures of powdered or microcrystalline hydrogel preparations with surfactant treated filler materials. The hydrogel preparations are located in a transverse band or strip extending across the width of the absorbent batt. U.S. Patent 4,333,485 discloses a sanitary towel which includes an absorptive hydrophilic fiber filling material. An internal core of the filling material has an insert which contains highly absorptive polymers therein. British Patent 1,408,815 describes absorbent pads which include absorptive gelling agents, such as cellulose ethers, cellulose esters, and acetyl starch. The gelling agent is impregnated into selected central areas of the pad.

The following patents disclose absorbent pads which include centralized layers or zones composed of material which are more absorbent than the other portions of the pad: U.S. Patent 1,702,530 U.S. Patent 3,073,309 and U.S. Patent 3,121,427.

U.S. Patent 3,889,103 discloses absorbent articles comprised of body-conforming supports which contain dry, solid, water-swellaable, water-insoluble polymeric sorbents composed of lightly cross-linked polymers. U.S. Patent 3,870,731 discloses an absorbent dressing which includes a water soluble hydrocolloid composition. The hydrocolloid can be intermixed with the fibers of an absorbent pad, or may be located in a discrete layer along a major surface of the absorbent article.

Further, absorbent pads are known which have included superabsorbent particles disposed in strip-type patterns. For example, U.S. Patent 3,888,798 describes an absorbent pad in a C-fold configuration which has a middle portion thereof loaded with a uniform dispersion of hydrocolloid polymer particles. U.S. Patent 4,410,324 describes a disposable diaper which has an absorbent pad folded intermediate the ends to provide increased absorbent material in the crotch region. Hydrocolloid material can be located in stripes along marginal portions of the absorbent pad.

U.K. Patent Application GB 2 145 881A describes an absorbent article comprised of at least two discrete super absorbent layers and a wicking means. The wicking means extends about and between the superabsorbent layers to help distribute liquid.

GB-A-21 31 348 describes a superthin absorbent disposable product having a compressed fibrous web as an absorbing layer, superabsorbent particles being interspersed and fixed in said absorbing layer and an associated wicking layer.

Conventional absorbent articles, such as those described above, have not been able to efficiently utilize the full potential of the superabsorbent materials. When the superabsorbent materials absorb liquid, they typically swell and form a gel structure. This gel structure often blocks the further transfer of liquid into the remaining absorbent structure. As a result, the liquid may be unable to reach the remaining super absorbent material and the efficiency of the absorbent article decreases significantly. Attempts to overcome this "gel blocking" phenomenon have included various techniques. For example, the technique of uniformly dispeneing the superabsorbent particles within a pad of absorbent and the technique of employing discrete wicking mechanisms to distribute the liquid throughout the quantity of superabsorbent have been employed. However, conventional techniques to reliably distribute the liquid and fully utilize the total amount of superabsorbent material have not been completely satisfactory.

A further shortcoming exhibited by conventional absorbent structures employing superabsorbents has been an undesirable, slippery and gel-like feeling produced on the surfaces of the absorbent structure. This slimy feeling has been particularly objectionable in absorbent pads incorporated into garments such as infant diapers, incontinence garments and feminine napkins. Conventional absorbent articles have ad-

TABLE 3

PERFORMANCE VS. SUPERABSORBENT Z-DIRECTIONAL DISTRIBUTION

| OVERNIGHT<br>TEST PRODUCT       | BODYSIDE/OUTER SIDE<br>SAM<br>DIST. RATIO (AREA) | % URINE ONLY<br>DIAPERS<br>W/SAM ON BSL | LKG 50 (b) |
|---------------------------------|--------------------------------------------------|-----------------------------------------|------------|
| 4g SANWET IM1000/<br>30g fluff  | 1:27                                             | 21%                                     | 250g       |
| 4g SANWET IM1000/<br>30g fluff  | 1:1.5                                            | 40%                                     | 195g       |
| 4g DOW DRYTECH SAM<br>30g fluff | 1:27 (a)                                         | 8%                                      | 247g       |
| 4g DOW DRYTECH SAM<br>30g fluff | 1:1.5 (a)                                        | 19%                                     | 223g       |

- (a) Distribution ratio based on qualitative analysis.  
 (b) An LKG 50 value of 250 grams means that 50% of the tested diapers failed before absorbing 250 grams of liquid during overnight use.

SAM = Superabsorbent material  
 BSL = Bodyside liner

Having thus described the invention in rather full detail, it will be readily apparent that various changes and modifications can be made, all of which are contemplated as being within the scope of the invention as defined by the subjoined claims.

Claims

1. An absorbent article comprising: a layer of absorbent material having a body side and an outside, particles of superabsorbent material distributed within said absorbent material layer; said superabsorbent particles being disposed to form a substantially continuous positive concentration gradient of superabsorbent through at least a portion of the thickness of said absorbent layer between the bodyside and the outside thereof,

wherein the ratio of the superabsorbent concentration at the beginning of said gradient taken at a point proximate the bodyside of the layer, at which the superabsorbent concentration has a substantially non-zero value and begins a gradual increase, to the superabsorbent concentration at the end of said gradient is at least about 1:3, as determined when the superabsorbent concentrations are measured on a weight percent basis, and wherein a concentration gradient line representing said concentration gradient of superabsorbent is a line having a positive slope within the range of 0.05-0.2 as determined by change in percent areal superabsorbent concentration divided by the percentage of the thickness of said layer over which the concentration change occurs.

2. An article as claimed in claim 1 wherein the superabsorbent concentration increases from the bodyside of said absorbent layer to the outer surface of said layer.

3. An absorbent article as claimed in claim 1 or 2, wherein the superabsorbent concentration at the bodyside surface of said absorbent layer is less than the average superabsorbent concentration of said absorbent layer, and the superabsorbent concentration at the outer surface of said absorbent layer is greater than said average superabsorbent concentration.

4. An absorbent article as claimed in claim 1 wherein the superabsorbent concentration is greater at locations partially through the thickness of said absorbent layer than at the bodyside and outer surfaces thereof.
5. An absorbent article as claimed in claim 4 wherein the superabsorbent concentration is substantially zero for a discrete distance measured into said absorbent layer from the bodyside surface thereof.
6. An absorbent article as claimed in claim 4 or 5 wherein the superabsorbent concentration is substantially zero for a discrete distance measured into said absorbent layer from the outer surface thereof.
7. An absorbent article as claimed in any preceding claim wherein the positive superabsorbent concentration gradient gradually increases as the superabsorbent concentration is measured at increasing distance away from the bodyside surface of said absorbent layer.
8. An absorbent article as claimed in any preceding claim wherein the superabsorbent particles located near the bodyside surface of said absorbent layer are on the average larger than the superabsorbent particles located near the outer surface of said absorbent layer.
9. An absorbent article as claimed in claim 8, wherein the superabsorbent particles near the bodyside surface of said absorbent layer range from about 300-1,000  $\mu\text{m}$  in size.
10. An absorbent article as claimed in claim 8 wherein the superabsorbent particles located at the outer surface of said absorbent layer are less than about 300 $\mu\text{m}$  in size.
11. An article as claimed in any preceding claim wherein said superabsorbent particles are substantially uniformly distributed across the width of said absorbent layer, as measured at a particular thickness level in the absorbent layer.
12. An article as claimed in any preceding claim, wherein said superabsorbent particles are substantially uniformly distributed along the length of said absorbent layer, as measured at a particular thickness level in the absorbent layer.
13. An article as claimed in any preceding claim wherein the ratio of the superabsorbent concentration at the beginning of said gradient to the superabsorbent concentration at the end of said gradient is at least about 1:11, as determined when the superabsorbent concentrations are measured on a weight percent basis.
14. An article as claimed in any preceding claim wherein the ratio of the superabsorbent concentration at the beginning of said gradient to the superabsorbent concentration at the end of said gradient is at least about 1:30, as determined when the superabsorbent concentrations are measured on a weight percent basis.
15. An absorbent article, comprising: a layer of absorbent material having a bodyside and an outside; particles of superabsorbent material distributed within said absorbent material layer; said superabsorbent particles being disposed to form a substantially continuous, non-step wise positive concentration gradient of superabsorbent through at least a portion of the thickness of said absorbent layer between the bodyside and the outside thereof; wherein the ratio of the superabsorbent concentration at the beginning of said gradient (taken at a point proximate the bodyside of the layer where the areal percent superabsorbent concentration is at least 0.21%) and begins a gradual increase, to the superabsorbent concentration at the end of said gradient is at least about 1:2, as determined when the superabsorbent concentrations are measured on an area percent basis and wherein a concentration gradient line representing said concentration gradient of superabsorbent is a line having a positive slope within the range of 0.02 - 0.5, as determined by change in percent areal superabsorbent concentration divided by the percentage of the thickness of said layer over which the concentration change occurs.
16. An absorbent article as recited in claim 15, wherein said ratio of superabsorbent concentration is at least about 1:5.

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17. An absorbent article as recited in claim 15 or 16, wherein said ratio of superabsorbent concentrations is at least about 1:10.
18. An absorbent article as recited in claim 15 to 17, wherein said concentration gradient line representing said concentration gradient of superabsorbent is a line having a positive slope within the range of 0.03 - 0.4, as determined by change in percent areal superabsorbent concentration divided by the percentage of the thickness of said layer over which the concentration change occurs.
19. An absorbent article as recited in claim 15 to 18, wherein said concentration gradient line representing said concentration gradient of superabsorbent is a line having a positive slope within the range of 0.05 - 0.2, as determined by change in percent areal superabsorbent concentration divided by the percentage of the thickness of said layer over which the concentration change occurs.

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Abstractive article.

Absorptive articles such as catamenial napkins and disposable diapers have improved properties if the fluid-absorptive material of such articles are formed at least in part of compressed cellulose-based sponge sheet obtained by compressing cellulose-based sponge.

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Description

ABSORPTIVE ARTICLE

The present invention relates to a fluid-absorptive article such as a catamenial napkin or disposable diaper.

5 A fluid-absorptive article such as catamenial napkin or disposable diaper commercially available today generally comprises a fluid-absorptive material of cotton-like pulp, absorbent paper, hygroscopic polymer or the like, a leakproof material of polyethylene film, waterproof paper or the like adjacent a portion of the outer surface of the fluid-absorptive material, and a fluid-permeable outer surface material.

10 However, conventional absorptive articles of this kind formed from cotton-like pulp or paper generally do not have the strength and shape-retainability which would be desired, and there is also the problem that the absorptive material tends to be broken or kinked, to form lumps, by the movement of the body as the absorptive article is being worn. Moreover, these problems are most conspicuous after a body fluid such as catamenial blood or urine has been absorbed, which accounts for the principal cause for the leakage of catamenial blood or urine.

15 With these problems in mind, it has been proposed to use polyurethane foam as the fluid-absorptive material (see Japanese Patent Laid Open, Gazette No. 57-150958 and Japanese Patent Laid Open, Gazette No. 80-42418). Although such use of polyurethane foam has some advantages over cotton-like pulp, it has inferior absorptive properties, such as a poorer rate of absorption of, and a lower absorption capacity for, body fluids. Moreover, it is liable to generate noxious gasses when the used article is incinerated. Accordingly, the use of polyurethane foam cannot be judged to be satisfactory when it is evaluated from the overall viewpoint.

20 In accordance with the present invention there is provided an absorptive article comprising a fluid-absorptive material, wherein at least a part of the fluid-absorptive material is constituted by compressed cellulose-based sponge sheet obtained by compressing cellulose-based sponge.

25 As the Examples below demonstrate, by using compressed cellulose-based sponge sheet material as taught by the present invention it is possible to provide an absorptive article of improved strength and shape retainability when wetted, particularly as compared with the use of cotton-like pulp or absorbent paper as the fluid-absorptive material. Absorptive articles made in accordance with this invention can thus be more comfortable to wear, since they have a reduced tendency to lumpiness when wet. Moreover, and unlike polyurethane foam, cellulose-based sponge material does not give rise to noxious gasses when incinerated.

30 It is preferred that the compressed cellulose-based sponge sheet should have a density in the range of 0.1 to 0.8 g/cm<sup>3</sup>, more preferably 0.3 to 0.6 g/cm<sup>3</sup>, and a percentage of voids in the range of 40% to 80%, more preferably from 50% to 80%.

35 In forming fluid-absorptive material using compressed cellulose-based sponge sheet, one may either make use of a single thicker sheet or a plurality of thinner sheets which may be laminated together. By giving the fluid-absorptive material a laminated structure, the flexibility of the material can be increased as compared with the use of a single thick sheet, so that in the case of articles such as catamenial napkins and disposable diapers a more satisfactory sensation of fitted wear as well as an improved absorptivity of body fluids can be obtained.

40 In addition, slits, in various patterns can be provided in the cellulose-based sponge sheets to improve further the comfort of fitted wear by enhancing the flexibility of the fluid-absorptive material, as well as to increase the rate of fluid absorption by increasing the fluid-absorbing area.

Moreover, by including a hygroscopically swelling polymer in the fluid-absorptive material it is possible to markedly increase the absorption capacity for body fluids, as well as help to prevent exudation of the body fluid to the outside.

45 Embodiments of the present absorptive article will now be described in detail with reference to the accompanying drawings, in which:

Fig. 1 is a sectional view of one embodiment of an absorptive article in accordance with the present invention;

Fig. 2 is a sectional view of another embodiment of absorptive article of the present invention;

Fig. 3 is a plan view of a fluid-absorptive material of this invention provided with slits; and

50 Figs. 4A to 4Q are plan views showing various alternative slit patterns for the fluid-absorptive material.

The absorptive article shown in Fig. 1 comprises a fluid-absorptive material 1 for absorbing and holding a body fluid such as catamenial blood or urine, a leakproof material 2 consisting of a fluid-impermeable material such as polyethylene film or waterproof paper, and an outer surface material 3 consisting of a fluid-permeable material such as woven fabric.

55 The fluid-absorptive material 1 is formed by laminating a plurality of compressed cellulose-based sponge sheets 1a (here illustrated as four sheets) obtained by compressing cellulose-based sponge. A hygroscopically swelling polymer 4 is included in the fluid-absorptive material 1.

60 The cellulose-based sponge is a sponge of a material containing a cellulose skeleton. Examples of such sponges include, in addition to sponges consisting of cellulose itself, sponges consisting of a cellulose derivative such as viscose, a cellulose ether and a cellulose ester, and sponges consisting of mixtures of those materials just mentioned. By compressing such cellulose sponges with a roller, there is formed a compressed cellulose-based sponge sheet 1a having a network structure which contains air bubbles. It is preferred that the compressed material should have a density of 0.1 to 0.8 g/cm<sup>3</sup>, more preferably 0.3 to 0.6 g/cm<sup>3</sup>, and a percent

of voids of from 40%, more preferably of 50% to 80%. The absorber 1 here illustrated is formed by laminating a plurality of the sheets 1a, which preferably have a thickness of about 0.05 - 2.0 mm.

An example of one suitable method for obtaining the cellulose-based sponge is as follows:

(1) Cellulose is converted to alkali cellulose with an alkali, then cellulose xanthate is obtained by subjecting the product to xanthation using carbon disulfide, and viscose is prepared by further adding sodium hydroxide solution. Glauber's salt, reinforcing fiber, and others are added to the viscose which is obtained by the dissolving cellulose, the mixture is extruded thinly by the use of a device such as a T-die, and the product is solidified by heating. The product is washed with water, treated with diluted sulfuric acid solution, washed again with water, neutralized with sodium carbonate and washed with water again, and dried to obtain cellulose-based sponge.

(2) Cellulose-based sponges of predetermined thickness is obtained by slicing, with a slicer, a thick sheet-form or block-form cellulose-based sponge prepared as described in step (1). It is desirable to slice the sponge in a moisture-bearing state and dry it after slicing.

Prior to compressing the cellulose-based sponge obtained in this way, it typically has a density in the range of 0.01 to 0.2 g/cm<sup>3</sup>, and a compressive deformation factor in the range of 10% to 80% under a load of 45 g/cm<sup>2</sup>.

Although the fluid-absorptive material can be formed by a single thick sheet of compressed cellulose-based sponge, the flexibility and hence the wear comfort of the article as a whole can be improved if the fluid-absorptive material is made by using a plurality of thinner compressed cellulose-based sponge sheets, as shown in Figures 1 and 2, is so as to form a laminate. In addition, the absorptivity of body fluid is greater because each sheet 1a is relatively thin, and penetration of the absorbed body fluid to the various layers is facilitated, so that the rate of absorption of the fluid-absorptive material as a whole is high.

Further, by the use of one or a plurality of the compressed cellulose-based sponge sheets 1a in accordance with this invention, the absorptive article can not only be formed compactly but it also has improved absorptivity characteristics, such as the rate of absorption and the volume of absorption, of body fluids. This is because when the article makes contact with body fluid, the fluid-absorptive material 1 absorbs the body fluid quickly and with a large capacity while its own volume increases substantially, generally from about 2 to 20 times, and usually from 5 to 15 times its volume at the time of compression.

As the hygroscopically swelling polymer 4 which is incorporated in the compressed cellulose-based sponge in the preferred embodiments of this invention, it is desirable to employ a polymer which can absorb water to more than 10 times its own weight. Such polymers are known and include, for example, the hydrolysis product of acrylonitrile grafted starch, crosslinked body of polyacrylate, polyvinyl alcohol, block copolymer of acrylic acid (acrylate), crosslinked body of carboxymethyl cellulose, and denatured polyvinyl alcohol. The hygroscopically swelling polymer 4 may be used in various forms such as that of granules, powders, and fibers, there being nothing critical about the form. Further, the hygroscopically swelling polymer 4 may be combined with the fluid-absorptive material 1 in numerous ways, including, for example, by dispersing it in the sponge, by interposing it between the sheets, and by impregnating the sponge with a monomer of the hygroscopically swelling polymer and then allowing it to be incorporated in the sponge subsequent to the polymerization and crosslinking reactions that take place in this state. The desirable content of the hygroscopically swelling polymer in the absorber is usually in the range of 5% to 70% by weight.

In addition, another method for enhancing the absorption characteristic of the fluid-absorptive sponge material 1 is by introducing a substitution group such as carboxyl group into the sponge in a post-forming process or in the manufacturing process.

In laminating a plurality of compressed cellulose-based sponge sheets, the wear comfort of the article can be enhanced further by alternately staggering these sheets slightly in the widthwise direction, as shown in Fig. 2, although they may be laminated by precisely overlapping them in the vertical direction. In addition, as another method of achieving lamination, a compressed cellulose-based sponge with a predetermined width can be obtained by folding back, toward the centre, the ends of compressed cellulose-based sponge sheets of greater width.

In the compressed cellulose-based sponge sheets from which the fluid-absorptive material is made, a plurality of slits with appropriate spacing may be provided, as shown in Fig. 3. The slits 5 further increase the flexibility of the material 1 which in turn enhances further the sensation of a better fit, as well as increasing the rate of absorption by enlarging the area for absorption of body fluids. That is, body fluid is absorbed not only through the side faces of the slits 5, but also through the rear surface of the fluid-absorptive material 1 which it reaches via the slits 5, so that the rate of absorption is enhanced as compared with the case where no slits are provided. The length, form, direction, and so forth of the slits can be widely varied, and Figs. 4A to 4Q illustrate a number of different slit patterns which can be employed.

The invention is further illustrated by the following Examples.

#### Example 1

Viscose sponge (bulk density of 0.045 g/cm<sup>3</sup>) of thickness 10 mm was compressed with a roller to form a number of sheets with densities in the range of 0.3 to 0.6 g/cm<sup>3</sup>. The resulting sheets were then used as fluid-absorptive material in catamenial napkins which were formed by wrapping the sides, rear surface, and a