

98/48

Clarke, Modet & Cº

COLOMBIA

SEÑORES
DIVISIÓN DE NUEVAS CREACIONES
SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO
E. S. D.

SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO
Rad: 05-118379- -00003-0000
Fec: 2006-05-30 16:35:42 Dep. 2020 NUECREACIONES
Tra. 11 PATENTEIYII
Cve: 379 FASENACIONALII
Act 444 RESPUESTAREQUE Folios: 44

REF: EXPEDIENTE No. 05118379
SOLICITANTE: DREXEL UNIVERSITY
GELIFEX, INC.
FECHA DE LA SOLICITUD: NOV. 22, 2005
TITULO: MEZCLAS DE POLIMERO TERMOGELIFICANTE PARA
APLICACIONES DE BIOMATERIAL

ASUNTO: CONTESTACIÓN A REQUERIMIENTO OFICIAL

DILIA RODRIGUEZ D'ALEMAN, en mi condición de apoderada de la sociedad solicitante, por el presente escrito doy respuesta a su auto notificado por estado de Enero 27 de 2006, que vence Marzo 27 de 2006 y del cual solicité una prórroga y me permito presentar los siguientes documentos y aclaraciones:

- El documento de PODER otorgado a mi favor, junto con la prueba de existencia y representación legal del solicitante, debidamente legalizados correspondiente a los dos solicitantes Drexel University y Gelifex Inc.
- Su traducción oficial al Español debidamente avalada por el Ministerio de Relaciones Exteriores.
- El documento en el que consta la CESIÓN del derecho a la patente otorgado por los inventores a los solicitante.
- Su traducción oficial al Español.
- Reporte de búsqueda y opinión escrita

Ruego a usted continuar con el presente trámite.

Señor Jefe


DILIA RODRIGUEZ D'ALEMAN
TLR/srr
P. 702

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TRADUCCIÓN OFICIAL No. 06/242 de un documento escrito en inglés, el cual para su identificación se sella con el sello del traductor al tiempo con la presente. Esta traducción ha sido preparada por Juan Pablo Piedrahita Aguilera, Traductor e Intérprete Oficial debidamente reconocido de conformidad con el Certificado de Idoneidad Profesional No. 0045 expedido por la Universidad Nacional de Colombia, por el Ministerio de Relaciones Exteriores y autorizado por el Ministerio del Interior y de Justicia, por resolución número 718 de 2003.

(Se traduce un Poder, otorgado por la compañía GELIFEX, INC., firmado por Troy Suihl, con fecha 6 de Diciembre, 2005, certificado notarial y Apostilla No. 200614440, escritos en inglés.)

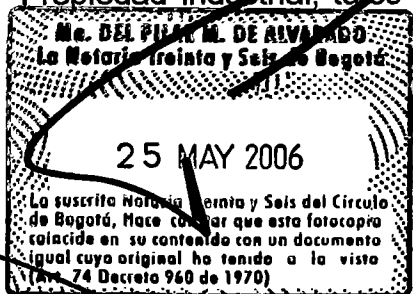
COLOMBIA

(Dirección en español)

PODER

Yo el suscrito, representante legal de GELIFEX, INC., sociedad constituida y existente bajo las leyes del Estado de Pensilvania, Estados Unidos de América y en actual cumplimiento de su objeto social, con domicilio en 1302 Wrights Lane East, West Chester, Pensilvania 19380, Estados Unidos de América, por el presente por el presente confiero (conferimos) poder especial a favor de a DILIA MARÍA RODRÍGUEZ D'ALEMÁN, identificada con cédula de ciudadanía No. 41.654.882 de Bogotá y Tarjeta Profesional 20824 y CLAUDIA LUCIA CARO RAMIREZ, identificada con Tarjeta Profesional 36448 y cédula de ciudadanía No 40.017.374 de Tunja, con domicilio en Bogotá, Colombia, para que actuando en su orden en nombre de la otorgante la representen ante cualquier entidad, autoridad y/o persona, especialmente ante las del orden Administrativo, Contencioso Administrativo, Judicial, Tribunales de Arbitramento y/o cualquier otro en lo referente a lo siguiente: MEZCLAS DE POLÍMERO TERMOGELIFICANTE PARA APLICACIONES DE BIOMATERIAL

1) Solicitar, tramitar, obtener y/o registrar cualesquiera de las modalidades de Propiedad Industrial, tales como: Patentes de Invención, Modelos de Utilidad;



TRADUCCION OFICIAL No. 06/242
JUAN PABLO PIEDRAHITA AGUILERA
TRADUCTOR E INTERPRETE OFICIAL
RES. 116 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA

Diseños Industriales, variedades vegetales, Marcas, Lemas, Nombres y Enseñas Comerciales y Denominaciones de Origen; así como sus renovaciones, prórrogas, traspasos, cambios de nombre y/o domicilio, contratos y licencias.

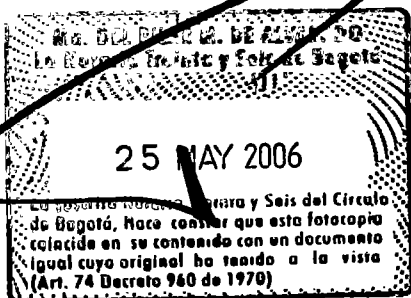
2) Solicitar, tramitar, obtener, y/o registrar derechos de autor, en cualquiera de sus presentaciones así como la protección de secretos industriales y know-how.

3) Solicitar, tramitar, obtener y/o registrar registros sanitarios, permisos y/o licencias de funcionamiento; así como sus renovaciones o prórrogas, cesiones, traspasos, cambios de nombre y/o domicilio, contratos y licencias.

4) Ejercer acciones de oposición, observación, reclamos, reivindicaciones, reconsideración, reposición, apelación, cancelación administrativa o judicial, nulidad, protección al consumidor, concesión de licencias, protección de secretos industriales y demás acciones y recursos relacionados con derechos derivados de los asuntos arriba indicados y en contra de la competencia desleal, acciones derivadas de la obtención o explotación de licencias, acciones de indemnización de perjuicios. También podrán intervenir en juicios civiles, comerciales, penales, contencioso-administrativos, tutelas y de policía; acciones o juicios promovidos por el mandante o contra él.

5) Registrar nombres de dominio ante la entidad competente.

6) En el ejercicio de este mandato los mandatarios arriba mencionados quedan facultados para: conciliar, cancelar, transigir, aceptar cláusulas



compromisorias, desistir, recibir y tomar posesión de la cosa objeto de litigio y renunciar o desistir derechos concedidos o en curso de concesión, admitir los hechos del proceso.

7) Ratificar o no la agencia oficiosa.

8) Así mismo facultamos a los mencionados apoderados para recibir notificaciones y designar apoderados judiciales o extrajudiciales, sustituir el presente poder y revocar las sustituciones que hicieren.

Dado y firmado en (en blanco), hoy día 6 de Diciembre, 2005.

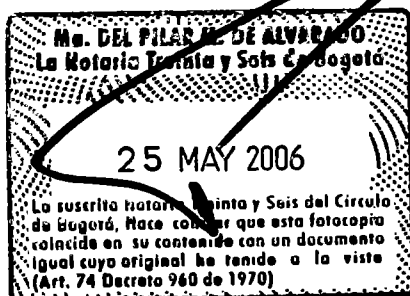
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CERTIFICADO NOTARIAL (Cuando el solicitante es una SOCIEDAD)

(Poderes otorgados en El Salvador, México, Estados Unidos de América y Venezuela)

Expedido hoy día 6 de Diciembre, 2005, el suscrito Notario CERTIFICA que:

- 1). Troy Suihl, (nombre de quien firma el poder), mayor de edad y domiciliado en Bensalem PA, suscribió el anterior documento.
- 2) El otorgante le es conocido personalmente y tiene capacidad para firmar el documento.
- 3) El otorgante ha suscrito el anterior documento en su calidad de Asesor Legal de Patentes de la persona jurídica GELIFLEX INC.
- 4) La mencionada persona jurídica con domicilio comercial en EL Estado de Pensilvania, Estados Unidos de América, está debidamente constituida, tiene



TRADUCCION OFICIAL No. 06/242
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actualmente existencia legal y el fin para el cual se otorga este poder se encuentra dentro de su objeto social.

5) El otorgante tiene en efecto la capacidad referida y su representación es legal y está autorizado para otorgar este poder.

6) Fundamento las certificaciones 3), 4) y 5) en los documentos auténticos que para tal fin me fueron exhibidos.

(Firmado) Joanna Franklin Range, Notario Público

(Sello Notarial a tinta: Sello Notarial, Joanna Franklin Range, Notario Público, West Goshen Twp., Condado de Chester, Mi comisión vence Agosto 18, 2008).

Nota: El Consulado de Colombia debe autenticar la firma del Notario Público.

Para todos los demás países el Señor Cónsul de Colombia o ante quien se otorgue, debe expedir una certificación dejando constancia de: 1) la existencia legal de la sociedad, 2) que cumple actualmente con su objeto social, y 3) que la persona o personas que otorgan este poder están facultadas para hacerlo. El Cónsul también certificará que los tuvo a la vista los documentos que prueban y acreditan tales circunstancias.

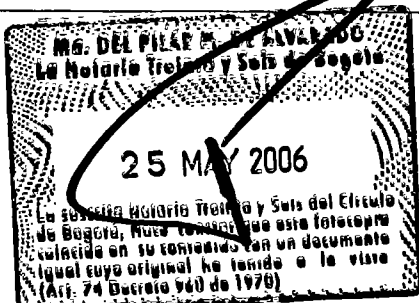
LEGALIZACIÓN POR EL CÓNSUL DE COLOMBIA A O POR APOSTILLA

APOSTILLA

(Convenio de la Haya de Octubre 5 de 1961)

1. País: Estados Unidos de América
Este documento público
2. Ha sido firmado por Joanna Franklin Range

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TRADUCCION OFICIAL No. _____
JUAN PABLO MED. ANITA MED. LERA
TRADUCTOR E INTERPRETE OFICIAL
RES. 710 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA

P. 702.

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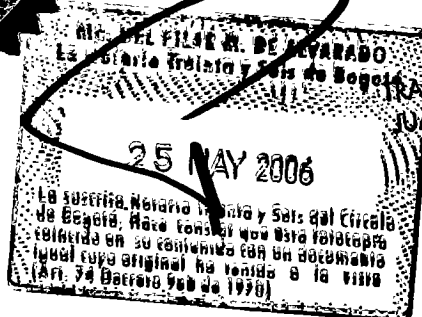
APOSTILLE

(Convention de La Haye du 5 octobre 1961)

1. Country : United States Of America
2. This public document has been signed by **JOANNA FRANKLIN RANGE**
3. acting in the capacity of **NOTARY PUBLIC**
4. bears the seal/stamp **JOANNA FRANKLIN RANGE, NOTARY PUBLIC, CHESTER COUNTY, COMMONWEALTH OF PENNSYLVANIA**
5. at Harrisburg, Pennsylvania
6. The 11th day of April, 2006
7. by Pedro A. Cortés, Secretary of the Commonwealth of Pennsylvania
8. No : 200614440
9. Seal/Stamp
10. Signature

Certified

Pedro A. Cortés
Pedro A. Cortés



06/242
TRADUCCION OFICIAL No. _____
JUAN PABLO RICO ARIAS AGUILERA
TRADUCTOR E INTERPRETE OFICIAL
RES. 116 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA

COLOMBIA

Carrera 11 N° 86-53 Piso 6 Bogotá Colombia Tel: (57 1) 6181088 Fax: (57 1) 6350824 Email: info@clarkmodel.com.co

PODER

Yo (nosotros), abajo firmante(s)

en mi (nuestro) carácter de representante(s) legales de

una sociedad organizada y existente de acuerdo con las leyes de

y en actual cumplimiento de su objeto social, con domicilio en

por el presente instrumento confiero (conferimos) poder especial a favor de DILIA MARIA RODRIGUEZ D'ALEMAN, con Cédula de Ciudadanía No. 41.654.882 de Bogotá, y tp. 20824 y CLAUDIA LUCIA CARO RAMIREZ, con Cédula de Ciudadanía No. 40.017.374 de Tunja, y tp. 36448, con domicilio en Bogotá, Colombia, para que actuando en su orden en nombre del (de la) otorgante le (la) representen ante cualquier entidad, autoridad y/o persona, especialmente ante las del orden Administrativo, Contencioso Administrativo, Judicial, Tribunales de Arbitramento y/o cualquier otro en lo referente a los siguientes asuntos:

- 1) Solicitar, tramitar, obtener y/o registrar cualquiera de las modalidades de Propiedad Industrial, tales como: patentes de invención, modelos de utilidad; diseños industriales, variedades vegetales; marcas, lemas, nombres y enseñanzas comerciales y denominaciones de origen; así como sus renovaciones, prórrogas, transferencias, cambios de nombre y/o domicilio, contratos y licencias.
- 2) Solicitar, tramitar, obtener y/o registrar derechos de autor, en cualquiera de sus presentaciones así como la protección de secretos industriales y know-how.
- 3) Solicitar, tramitar, obtener y/o registrar registros sanitarios, permisos y/o licencias de funcionamiento; así como sus renovaciones o prórrogas, transferencias, cambios de nombre y/o domicilio, contratos y licencias.
- 4) Ejercer acciones de oposición, observación, reclamos, reconsideración, reposición, apelación, cancelación administrativa o judicial, nulidad, protección al consumidor, concesión de licencias, protección de secretos industriales y demás acciones y recursos relacionados con derechos derivados de los asuntos arriba indicados y en contra de la competencia desleal, acciones derivadas de la obtención o explotación de licencias, acciones de indemnización de perjuicios. También podrá(n) intervenir en juicios civiles, comerciales, penales, contencioso-administrativos, tutelas y de policía; en acciones o juicios promovidos por el (la) mandante o en contra el (ella).
- 5) Registrar nombres de dominio ante la entidad competente.
- 6) En el ejercicio de este mandato los mandatarios arriba mencionados quedan facultados para: conciliar, cancelar, transigir, comprometer en árbitros, desistir, recibir y tomar posesión de la cosa objeto de litigio y renunciar o desistir a derechos concedidos o en curso de concesión, admitir los hechos del proceso.
- 7) Ratificar o no la agencia oficiosa.
- 8) Así mismo faculto (facultamos) a los mencionados apoderados para recibir notificaciones y designar apoderados judiciales o extrajudiciales, sustituir el presente poder y revocar las sustituciones que hicieren.

Dado y firmado en

a los

días de

TRADUCCION OFICIAL No. 06/242
JUAN PABLO PIEDRAHITA ACUÑERA
TRADUCTOR E INTERPRETE OFICIAL
Res. 718 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA

POWER OF ATTORNEY

I (we), the undersigned

legal representative(s) of

GELIFEX, INC.

an organization existing under the laws of The state of

Pennsylvania, U.S.A.

and in present execution of its business activity, domiciled at

1302 Wrights Lane East
West Chester, Pennsylvania 19380
U.S.A.

do hereby grant POWER OF ATTORNEY to DILIA MARIA RODRIGUEZ D'ALEMAN, identification card No. 41.654.882 of Bogotá, and tp. 20824 and CLAUDIA LUCIA CARO RAMIREZ, tp. 36448, identification card No. 40.017.374 of Tunja, residing in Bogotá, Colombia, to act in the order of their appointment in behalf of grantor before any entity, authority and/or natural or juridical person, specially before those Administrative, Administrative-Contentious, Judicial, arbitration courts, and/or any other, in all matters concerning the following:

THERMOGELLING POLYMER BLENDS FOR BIOMATERIAL APPLICATIONS

- 1) To apply, process, obtain and/or register any of the modalities of Industrial Property, such as: Patents of Invention, Utility Models; Designs, plant varieties; Marks, Slogans, Trade Names and emblems and appellations of Origin; as well as their renewals, assignments, changes of name and/or domicile, agreements and licenses.
- 2) To apply, process, obtain and/or register copyrights of any kind as well as protection of industrial secrets or know-how.
- 3) To apply, process, obtain and/or register sanitary registrations, operating authorizations and/or licenses; as well as their renewals or assignments, changes of name and/or domicile, agreements and licenses.
- 4) To bring actions of opposition, observations, claims, reconsideration, appeal or legal remedies, cancellations, nullity, protection to the consumer, granting of licenses, protection of trade secrets and other actions related with rights derived from the above-mentioned matters and against the unfair competition, actions resulting from the obtaining or exploitation of licenses, recovering damages actions. They can also intervene or participate in Civil, Commercial, Criminal or Contentious-Administrative Trials; the actions for writ mandamus, police actions; in actions, lawsuits or litigations instituted by the grantor or against him.
- 5) To register domain names before the competent entity.
- 6) To the effect of this mandate the above-named proxy are empowered to: conciliate, cancel, settle, submit to arbitration, withdraw and to receive and take possession of the litigation related object and waive or renounce the rights granted or in process of granting, admit the facts of the case.
- 7) To ratify or not the officious agency.
- 8) I (we) hereby appoint the afore mentioned attorney with powers to receive notifications and to designate judicial and extrajudicial attorneys, substitute this Power of Attorney and to revoke such substitutions.

Granted and signed at

on this 6th day of December of 2005

Firma / signature

25 MAY 2006

La Subrita Notaria Treinta y Seis del Circuito de Bogotá, ha constatado que esta fotocopia coincide con el contenido con un documento igual cuyo original ha tenido a la vista (Art. 74 Decreto 960 de 1970)

CERTIFICADO NOTARIAL

(Cuando el solicitante es SOCIEDAD)

(Poderes otorgados en: El Salvador, Estados Unidos, México y Venezuela)

A los _____ días del mes de _____ de _____, el Notario que suscribe DA FE de que:

1. _____
(nombre de la persona que firma el poder)

mayor de edad y domiciliado en _____
_____ firmó de su puño
y letra el documento que antecede.

2. Conoce al (a la) otorgante y que este (a) está legalmente capacitado para el otorgamiento.

3. El otorgante ha firmado el referido documento en su carácter de _____
de la persona jurídica _____

4. La citada persona jurídica con sede en _____ está legalmente constituida, que tiene actualmente existencia legal y que el acto para el cual se ha otorgado este poder está comprendido entre los que constituyen su objeto social.
5. El otorgante tiene efectivamente la representación que ostenta, que esta es legítima y que está facultado para otorgar este poder.
6. las anteriores certificaciones de los puntos 3, 4 y 5, me constan porque he tenido a la vista los documentos auténticos.

Notario Público

NOTA: A continuación de lo anterior, el Cónsul de Colombia debe autenticar la firma del Notario Público.

CERTIFICADO NOTARIAL (Cuando el solicitante es INDIVIDUO)

A los _____ días del mes de _____ de _____, el Notario que suscribe DA FE de que:

1. _____
(nombre de la persona que firma el poder)

mayor de edad y domiciliado en _____
_____ firmó en su presencia
el documento que antecede, conoce al otorgante y que este está legalmente capacitado para el otorgamiento.

Notario Público

NOTA: A continuación de lo anterior, el Cónsul de Colombia debe autenticar la firma del Notario Público.

Para todos los demás países el Señor Cónsul de Colombia o ante quien se otorgue, debe expedir una certificación dejando constancia 1) de la existencia legal de la sociedad, 2) de que esta ejerce actualmente su objeto social, y 3) de que la persona o personas que otorgan el poder están facultadas para hacerlo, dejando constancia así mismo de que tuvo a la vista las pruebas que acrediten tales circunstancias.

LEGALIZACIÓN POR EL CONSUL DE COLOMBIA O POR APOSTILLA

NOTARIAL CERTIFICATE

(When the applicant is a CORPORATION)

(Powers of attorney granted in: El Salvador, Mexico, U.S.A. and Venezuela)

This 6th day of December, 2005
the undersigned Notary CERTIFIES that:

1. Troy Svihl
(name of the person who signs the power of attorney)

of _____ legal _____ age _____ and _____ domiciled
in Bensalem, PA set his hand on
the foregoing document.

2. The grantor is to him personally known and that he/she has legal capacity to execute the document.

3. The grantor has executed the foregoing document in his capacity of Patent Counsel
of the juridical person GELIFEX, INC.

4. The mentioned juridical person with place of business in the State of Pennsylvania, U.S.A. is duly organized, has actual legal existence and that the purposes for which the power of attorney is granted are within the scope of its corporate purposes.

5. The grantor has in fact the referred quality and that his/her representation is legal and that he/she is empowered to grant this power of attorney.

6. I have based the above certifications 3, 4 and 5, on the authentic documents which for such purpose were exhibited to me.

Joanna Franklin Range
Notary Public

NOTA: Then the Colombian Consul must legalize the signature of the Notary Public.

NOTARIAL CERTIFICATE (When the applicant is INDIVIDUALS)

On this _____ day of _____
the undersigned Notary CERTIFIES that:

1. _____
(name of the person who signs the Power of Attorney)

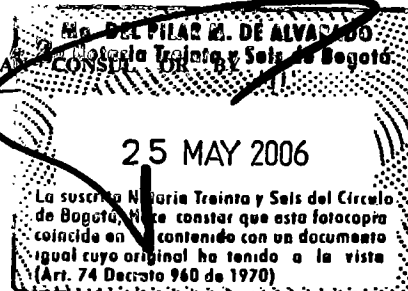
of legal age and domiciled at _____
_____ signed in his presence the foregoing
document, the grantor is to him personally known and that he/she has legal capacity to execute the document.

Notary Public

NOTA: Then the Colombian Consul must legalize the signature of the Notary Public.

For all other countries the Colombian Consul or before who it is granted must issue a certification stating 1) the legal existence of the corporation, 2) that the corporate purposes are actually being accomplished, 3) that the person or persons who grant this Power of Attorney are empowered to do it. The Consul will certify also that the documents evidencing those circumstances were exhibited to him.

LEGALIZATION BY THE COLOMBIAN CONSUL OR BY APOSTILLE
TRADUCCIÓN OFICIAL No. _____
JUAN PABLO PIEDRAHITA AGUILERA
TRADUCTOR E INTERPRETE OFICIAL
M.D. /18 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA



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TRADUCCIÓN OFICIAL No. 06/243 de un documento escrito en inglés, el cual para su identificación se sella con el sello del traductor al tiempo con la presente. Esta traducción ha sido preparada por Juan Pablo Piedrahita Aguilera, Traductor e Intérprete Oficial debidamente reconocido de conformidad con el Certificado de Idoneidad Profesional No. 0045 expedido por la Universidad Nacional de Colombia, por el Ministerio de Relaciones Exteriores y autorizado por el Ministerio del Interior y de Justicia, por resolución número 718 de 2003.

(Se traduce un Poder, otorgado por la compañía DREXEL UNIVERSITY, con fecha 15 de Diciembre, 2005, certificado notarial y Apostilla No. 200614441, escritos en inglés.)

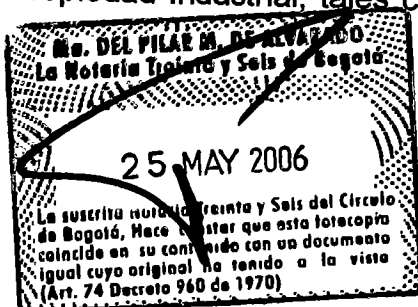
COLOMBIA

(Dirección en español)

PODER

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TRADUCTOR E INTERPRETE OFICIAL
Res. 718 de Mayo 2003
DEL MIN. INTERIOR Y DE JUSTICIA

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Diseños Industriales, variedades vegetales, Marcas, Lemas, Nombres y Enseñas Comerciales y Denominaciones de Origen; así como sus renovaciones, prórrogas, traspasos, cambios de nombre y/o domicilio, contratos y licencias.

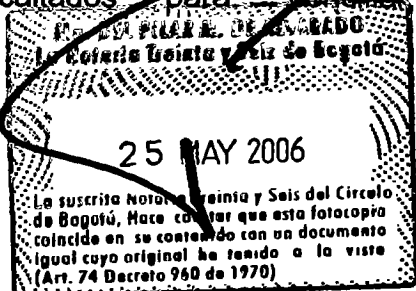
2) Solicitar, tramitar, obtener, y/o registrar derechos de autor, en cualquiera de sus presentaciones así como la protección de secretos industriales y "know-how".

3) Solicitar, tramitar, obtener y/o registrar registros sanitarios, permisos y/o licencias de funcionamiento; así como sus renovaciones o prórrogas, cesiones, traspasos, cambios de nombre y/o domicilio, contratos y licencias.

4) Ejercer acciones de oposición, observación, reclamos, reivindicaciones, reconsideración, reposición, apelación, cancelación administrativa o judicial, nulidad, protección al consumidor, concesión de licencias, protección de secretos industriales y demás acciones y recursos relacionados con derechos derivados de los asuntos arriba indicados y en contra de la competencia desleal, acciones derivadas de la obtención o explotación de licencias, acciones de indemnización de perjuicios. También podrán intervenir en juicios civiles, comerciales, penales, contencioso-administrativos, tutelas y de policía; acciones o juicios promovidos por el mandante o contra él.

5) Registrar nombres de dominio ante la entidad competente.

6) En el ejercicio de este mandato los mandatarios arriba mencionados quedan facultados para: conciliar, cancelar, transigir, aceptar cláusulas,



compromisorias, desistir, recibir y tomar posesión de la cosa objeto de litigio y renunciar o desistir derechos concedidos o en curso de concesión, admitir los hechos del proceso.

7) Ratificar o no la agencia oficiosa.

8) Así mismo facultamos a los mencionados apoderados para recibir notificaciones y designar apoderados judiciales o extrajudiciales, sustituir el presente poder y revocar las sustituciones que hicieren.

Dado y firmado en 3201 Arch St. Filadelfia, PA, 19601, hoy día 15 de Diciembre, 2005.

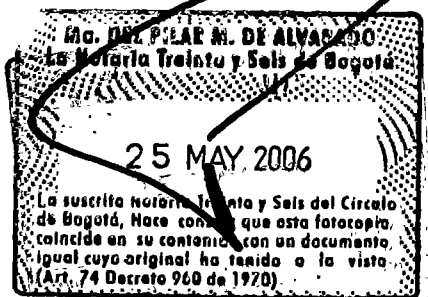
Por: (Firmado) Ilegible

CERTIFICADO NOTARIAL (Cuando el solicitante es una SOCIEDAD)

(Poderes otorgados en El Salvador, México, Estados Unidos de América y Venezuela)

Expedido hoy día 15 de Diciembre, 2005, el suscrito Notario CERTIFICA que:

- 1). Robert B. McGrath, (nombre de quien firma el poder), mayor de edad y domiciliado en 3201 Arch St. Filadelfia, suscribió el anterior documento.
- 2) El otorgante le es conocido personalmente y tiene capacidad para firmar el documento.
- 3) El otorgante ha suscrito el anterior documento en su calidad de Vicepresidente Asociado de la persona jurídica DREXEL UNIVERSITY.
- 4) La mencionada persona jurídica con domicilio comercial en EL Estado de



3

TRADUCCION OFICIAL No. 06 / 243
JUAN PABLO MEDRANITA AGUIRERA
TRADUCTOR E INTERPRETE OFICIAL
RES. 716 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA

Pensilvania, Estados Unidos de América, está debidamente constituida, tiene actualmente existencia legal y el fin para el cual se otorga este poder se encuentra dentro de su objeto social.

5) El otorgante tiene en efecto la capacidad referida y su representación es legal y está autorizado para otorgar este poder.

6) Fundamento las certificaciones 3), 4) y 5) en los documentos auténticos que para tal fin me fueron exhibidos.

(Firmado) Susan K. Phillips, Notario Público

Nota: El Consulado de Colombia debe autenticar la firma del Notario Público.

Para todos los demás países el Señor Cónsul de Colombia o ante quien se otorgue, debe expedir una certificación dejando constancia de: 1) la existencia legal de la sociedad, 2) que cumple actualmente con su objeto social, y 3) que la persona o personas que otorgan este poder están facultadas para hacerlo. El Cónsul también certificará que los tuvo a la vista los documentos que prueban y acreditan tales circunstancias.

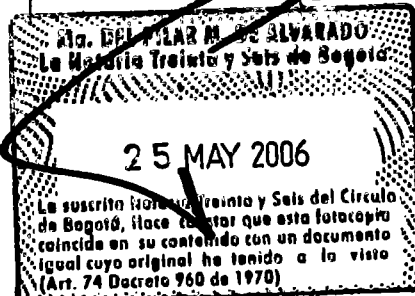
LEGALIZACIÓN POR EL CÓNSUL DE COLOMBIA A O POR APOSTILLA

(Sello Notarial a tinta: Sello Notarial, Susan K. Phillips, Notario Público, Ciudad de Pensilvania, Condado de Pensilvania, Mi comisión vence Agosto 25, 2008).

(Sello Notarial en Relieve)

APOSTILLA

(Convenio de la Haya de Octubre 5 de 1961)



4

06 / 243
TRADUCCION OFICIAL No. _____
JUAN PABLO GARCIA RODRIGUEZ
TRADUCTOR E INTERPRETE OFICIAL
RES. 718 DE MARZO 2003
DEL MIN. INTERIOR Y DE JUSTICIA

713

COLOMBIA

Carrera 11 N° 86-53 Piso 6 Bogotá Colombia Tel: (57 1) 6181088 Fax: (57 1) 6350824 Email: info@clarkemodet.com.co

PODER

Yo (nosotros), abajo firmante(s)

en mi (nuestro) carácter de representante(s) legales de

una sociedad organizada y existente de acuerdo con las leyes de

y en actual cumplimiento de su objeto social, con domicilio en

por el presente instrumento confiero (conferimos) poder especial a favor de DILIA MARIA RODRIGUEZ D'ALEMAN, con Cédula de Ciudadanía No. 41.654.882 de Bogotá, y tp. 20824 y CLAUDIA LUCIA CARO RAMIREZ, con Cédula de Ciudadanía No. 40.017.374 de Tunja, y tp. 36448, con domicilio en Bogotá, Colombia, para que actuando en su orden en nombre del (de la) otorgante le (la) representen ante cualquier entidad, autoridad y/o persona, especialmente ante las del orden Administrativo, Contencioso Administrativo, Judicial, Tribunales de Arbitramento y/o cualquier otro en lo referente a los siguientes asuntos:

- 1) Solicitar, tramitar, obtener y/o registrar cualquiera de las modalidades de Propiedad Industrial, tales como: patentes de invención, modelos de utilidad; diseños industriales, variedades vegetales; marcas, lemas, nombres y enseñas comerciales y denominaciones de origen; así como sus renovaciones, prórrogas, transferencias, cambios de nombre y/o domicilio, contratos y licencias.
- 2) Solicitar, tramitar, obtener y/o registrar derechos de autor, en cualquiera de sus presentaciones así como la protección de secretos industriales y know-how.
- 3) Solicitar, tramitar, obtener y/o registrar registros sanitarios, permisos y/o licencias de funcionamiento; así como sus renovaciones o prórrogas, transferencias, cambios de nombre y/o domicilio, contratos y licencias.
- 4) Ejercer acciones de oposición, observación, reclamos, reconsideración, reposición, apelación, cancelación administrativa o judicial, nulidad, protección al consumidor, concesión de licencias, protección de secretos industriales y demás acciones y recursos relacionados con derechos derivados de los asuntos arriba indicados y en contra de la competencia desleal, acciones derivadas de la obtención o explotación de licencias, acciones de indemnización de perjuicios. También podrá(n) intervenir en juicios civiles, comerciales, penales, contencioso-administrativos, tutelas y de policía; en acciones o juicios promovidos por el (la) mandante o en contra el (ella).
- 5) Registrar nombres de dominio ante la entidad competente.
- 6) En el ejercicio de este mandato los mandatarios arriba mencionados quedan facultados para: conciliar, cancelar, transigir, comprometer en árbitros, desistir, recibir y tomar posesión de la cosa objeto de litigio y renunciar o desistir a derechos concedidos o en curso de concesión, admitir los hechos del proceso.
- 7) Ratificar o no la agencia oficiosa.
- 8) Las personas aquí (facultamos) a los mencionados apoderados para que asuman los deberes y designar apoderados judiciales o extrajudiciales, La Notaría que tiene el poder y revocar las sustituciones que hicieren.

Dado y firmado en

2-5 MAY 2006 de

La suscrita Notaría, Treinta y Seis del Circuito de Bogotá, Hace constar que este fotocopia coincide en su contenido con un documento igual cuyo original he tenido (Art. 74 Decreto 940 de 1970)

TRADUCCION OFICIAL No.
 JUAN PABLO PIEDRAHITA RODRIGUEZ
 TRADUCTOR E INTERPRETE OFICIAL
 RES. 118 DE MARZO 2003
 DEL MIN. INTERIOR Y DE JUSTICIA

POWER OF ATTORNEY

I (we), the undersigned

legal representative(s) of

DREXEL UNIVERSITY

an organization existing under the laws of The state of

Pennsylvania, U.S.A.

and in present execution of its business activity, domiciled at

1302 Wrights Lane East
 West Chester, Pennsylvania 19380
 U.S.A.

do hereby grant POWER OF ATTORNEY to DILIA MARIA RODRIGUEZ D'ALEMAN, identification card No. 41.654.882 of Bogotá, and tp. 20824 and CLAUDIA LUCIA CARO RAMIREZ, tp. 36448, identification card No. 40.017.374 of Tunja, residing in Bogotá, Colombia, to act in the order of their appointment in behalf of grantor before any entity, authority and/or natural or juridical person, specially before those Administrative, Administrative-Contentious, Judicial, arbitration courts, and/or any other, in all matters concerning the following:

THERMOGELLING POLYMER BLENDS FOR BIOMATERIAL APPLICATIONS

- 1) To apply, process, obtain and/or register any of the modalities of Industrial Property, such as: Patents of Invention, Utility Models; Designs, plant varieties; Marks, Slogans, Trade Names and emblems and appellations of Origin; as well as their renewals, assignments, changes of name and/or domicile, agreements and licenses.
- 2) To apply, process, obtain and/or register copyrights of any kind as well as protection of industrial secrets or know-how.
- 3) To apply, process, obtain and/or register sanitary registrations, operating authorizations and/or licenses; as well as their renewals or assignments, changes of name and/or domicile, agreements and licenses.
- 4) To bring actions of opposition, observations, claims, reconsideration, appeal or legal remedies, cancellations, nullity, protection to the consumer, granting of licenses, protection of trade secrets and other actions related with rights derived from the above- mentioned matters and against the unfair competition, actions resulting from the obtaining or exploitation of licenses, recovering damages actions. They can also intervene or participate in Civil, Commercial, Criminal or Contentious-Administrative Trials; the actions for writ mandamus, police actions; in actions, lawsuits or litigations instituted by the grantor or against him.
- 5) To register domain names before the competent entity.
- 6) To the effect of this mandate the above-named proxy are empowered to: conciliate, cancel, settle, submit to arbitration, withdraw and to receive and take possession of the litigation related objet and waive or renounce the rights granted or in process of granting, admit the facts of the case.
- 7) To ratify or not the officious agency.
- 8) I (we) hereby appoint the afore mentioned attorneys with powers to receive notifications and to designate judicial and extrajudicial attorneys, substitute this Power of Attorney and to revoke such substitutions.

Granted and signed at 3201 Arch St, Philadelphia, PA, 19101

on this 15th day of December of 2005

[Signature]
 Firma / signatura

CERTIFICADO NOTARIAL

(Cuando el solicitante es SOCIEDAD)

(Poderes otorgados en: El Salvador, Estados Unidos, México y Venezuela)

A los _____ días del mes de _____ de _____
el Notario que suscribe DA FE de que:

1. _____
(nombre de la persona que firma el poder)

mayor de edad y domiciliado en _____
firmó de su puño
y letra el documento que antecede.

2. Conoce al (a la) otorgante y que este (a) está legalmente capacitado para el otorgamiento.

3. El otorgante ha firmado el referido documento en su carácter de _____
de la persona jurídica _____

4. La citada persona jurídica con sede en _____
está legalmente
constituida, que tiene actualmente
existencia legal y que el acto para el cual se ha otorgado este
poder está comprendido entre los que constituyen su objeto social.
5. El otorgante tiene efectivamente la representación que ostenta, que
esta es legítima y que está facultado para otorgar este poder.
6. Las anteriores certificaciones de los puntos 3, 4 y 5, me constan porque
he tenido a la vista los documentos auténticos.

Notario Público

NOTA: A continuación de lo anterior, el Cónsul de Colombia debe
autenticar la firma del Notario Público.

CERTIFICADO NOTARIAL (Cuando el solicitante es INDIVIDUO)

A los _____ días del mes de _____ de _____
el Notario que suscribe DA FE de que:

1. _____
(nombre de la persona que firma el poder)

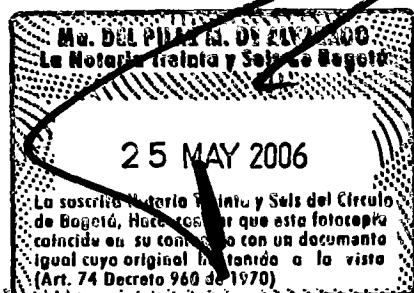
mayor de edad y domiciliado en _____
firmó en su presencia
el documento que antecede, conoce al otorgante y que este está
legalmente capacitado para el otorgamiento.

Notario Público

NOTA: A continuación de lo anterior, el Cónsul de Colombia debe
autenticar la firma del Notario Público.

Para todos los demás países el Señor Cónsul de Colombia o ante
quien se otorgue, debe expedir una certificación dejando constancia
1) de la existencia legal de la sociedad, 2) de que esta ejerce actual-
mente su objeto social, y 3) de que la persona o personas que otorgan
el poder están facultadas para hacerlo, dejando
constancia así mismo de que tuvo a la vista las pruebas que acrediten
tales circunstancias.

**LEGALIZACIÓN POR EL CONSUL DE COLOMBIA
O POR APOSTILLA**



NOTARIAL CERTIFICATE

(When the applicant is a CORPORATION)

(Powers of attorney granted in: El Salvador, Mexico, U.S.A. and Venezuela)

This 15th day of December, 2005
the undersigned Notary CERTIFIES that:

1. Robert B. McGrath
(name of the person who signs the power of attorney)

of _____ legal age and _____
domiciled in 3201 Arch St., Philadelphia set his hand on
the foregoing document.

2. The grantor is to him personally known and that he/she has legal capacity to execute the document.

3. The grantor has executed the foregoing document in his capacity
of Associate Vice Provost
of the juridical person DREXEL UNIVERSITY

4. The mentioned juridical person with place of business in the State of
Pennsylvania, U.S.A. is duly organized, has actual legal existence and that
the purposes for which the power of attorney is granted are within the scope
of its corporate purposes.

5. The grantor has in fact the referred quality and that his/her
representation is legal and that he/she is empowered to grant this power
of attorney.

6. I have based the above certifications 3, 4 and 5, on the authentic documents
which for such purpose were exhibited to me.

Notary Public

NOTA: Then the Colombian Consul must legalize the signature of the Notary
Public.

NOTARIAL CERTIFICATE (When the applicant is an INDIVIDUALS)

On this _____ day of _____
the undersigned Notary CERTIFIES that:

1. _____
(name of the person who signs the Power of Attorney)

of legal age and domiciled at _____
signed in his presence the foregoing
document, the grantor is to him personally known and that he/she has legal
capacity to execute the document.

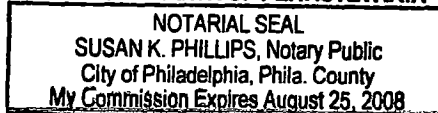
Notary Public

NOTA: Then the Colombian Consul must legalize the signature of the Notary
Public.

For all other countries the Colombian Consul or before who it is granted
must issue a certification stating 1) the legal existence of the corporation,
2) that the corporate purposes are actually being accomplished, 3) that
the person or persons who grant this Power of Attorney are empowered
to do it. The Consul will certify also that the documents evidencing those
circumstances were exhibited to him.

**LEGALIZATION BY THE COLOMBIAN CONSUL OR BY
APOSTILLE.**

COMMONWEALTH OF PENNSYLVANIA



TRADUCCION OFICIAL No. _____

JUAN PABLO RODRIGUEZ AGUILERA

TRADUCTOR E INTERPRETE OFICIAL

REC. 118 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA

775

TRADUCCIÓN OFICIAL No. 06/274 de un documento escrito en inglés, el cual para su identificación se sella con el sello del traductor al tiempo con la presente. Esta traducción ha sido preparada por Juan Pablo Piedrahita Aguilera, Traductor e Intérprete Oficial debidamente reconocido por el Ministerio del Interior y de Justicia, por resolución número 718 de 2003 y autorizado por el Ministerio de relaciones Exteriores de Colombia.

(Se traduce un documento de cesión a favor de DREXEL UNIVERSITY y GELIFLEX INC., sellos notariales y Apostillas Nos. 200614442 y 20061443, escritos en inglés.)

CLARKE, MODET & Co.

Colombia

CORREO-ELECTRÓNICO: clarkemodet@clarkemodet.com.co

SANTAFÉ DE BOGOTÁ, AA. 92397 COLOMBIA

CESIÓN

Los suscritos, (en adelante los CEDENTES) Anthony M. Lowman, Michele S. Marcolongo, Alastair J. T. Clemow en calidad de inventores/diseñadores de "MEZCLAS DE POLÍMERO TERMOGELIFICANTE PARA APLICACIONES DE MATERIAL ", con domicilio respectivamente en:

Wallingford, Pensilvania, EE.UU.

Aston, Pensilvania, EE.UU.

Princeton, New Jersey, EE.UU.

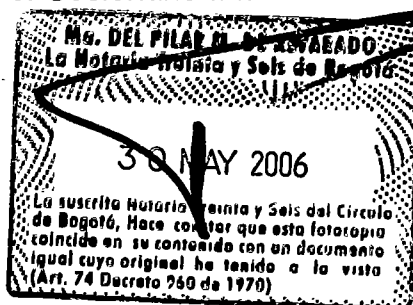
por el presente declara que cede todos y cada uno de los derechos y privilegios que le correspondan o que le puedan corresponder sobre la siguiente invención, diseño industrial o modelo de utilidad a

DREXEL UNIVERSITY y GELIFLEX INC

con domicilio respectivamente en:

Pensilvania, EE.UU. y Pensilvania, EE.UU.

El Cedente y el Cesionario firman este documento como prueba de aceptación de la cesión.



06

TRADUCCION OFICIAL No. _____
JUAN PABLO PIEDRAHITA AGUILERA
TRADUCTOR E INTERPRETE OFICIAL
RES. 718 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA

776

Dada y firmada a los 8 días del mes de Febrero, 2006.

(Firmado) Ilegible Anthony M Lowman

El Cedente

(Sello notarial a tinta: MANCOMUNIDAD DE PENSILVANIA, SELLO NOTARIAL, CHARLENE RICE, Notario Público, Ciudad de Filadelfia, Condado de Filadelfia, Mi comisión vence Diciembre 30, 2009)

Firmado y juramentado ante mí hoy día 8 de Febrero, 2006-05-30 (Firma del Notario)

(En español, Sello Notarial certificando la autenticidad de la fotocopia)

Dada y firmada a los 14 días del mes de Febrero, 2006.

(Firmado) Ilegible Michele S. Marcolongo

El Cedente

(Sello notarial a tinta: MANCOMUNIDAD DE PENSILVANIA, SELLO NOTARIAL, CHARLENE RICE, Notario Público, Ciudad de Filadelfia, Condado de Filadelfia, Mi comisión vence Diciembre 30, 2009)

Firmado y juramentado ante mí hoy día 8 de Febrero, 2006-05-30 (Firma del Notario)

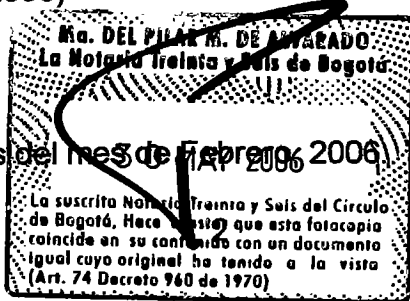
Dada y firmada a los 22 días del mes de Febrero, 2006.

(Firmado) Ilegible Alastair J. T. Clemow

El Cedente

(Sello notarial a tinta: MARIE S. PETER, Notario Público, NEW JERSEY, Mi comisión vence Junio 20, 2006)

Dada y firmada a los 8 días del mes de Febrero, 2006.



TRADUCCION OFICIAL No. _____
JUAN PABLO PIEDRAHITA AGUILERA
TRADUCTOR E INTERPRETE OFICIAL
RES. 718 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA

(Firmado) Ilegible Robert B. McBreth, Vicepresidente Asociado

El Cesionario

(Sello notarial a tinta: MANCOMUNIDAD DE PENSILVANIA, SELLO NOTARIAL, CHARLENE RICE, Notario Público, Ciudad de Filadelfia, Condado de Filadelfia, Mi comisión vence Diciembre 30, 2009)

Firmado y juramentado ante mí hoy día 8 de Febrero, 2006-05-30 (Firma del Notario)

Dada y firmada a los 15 días del mes de Febrero, 2006.

(Firmado) Ilegible Troy Suihl, Asesor Legal de Patentes

El Cesionario

(Sello notarial a tinta: MANCOMUNIDAD DE PENSILVANIA, SELLO NOTARIAL, JOANNA FRANKLIN RANGE, Notario Público, West Goshen Twp., Condado de Chester, Mi comisión vence Ilegible)

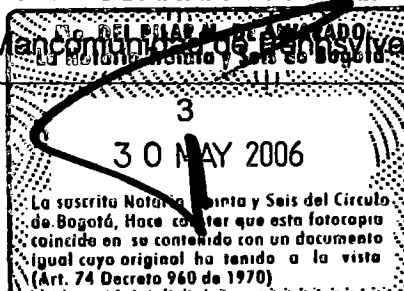
(Firma del Notario)

(Este documento debe ser otorgado ante Notario Público y legalizado por el Cónsul Colombia o mediante Apostilla).

APOSTILLA

(Convenio de la Haya de Octubre 5 de 1961)

1. País: Estados Unidos de América
Este documento público
2. Ha sido firmado por JOANNA FRANKLIN RANGE
3. Actuando en calidad de Notario Público
4. Lleva el sello/estampilla de JOANNA FRANKLIN RANGE, Notario Público, Condado de Chester, Mancomunidad de Pensilvania



TRADUCCION OFICIAL No. _____
JUAN PABLO PIEDRAHITA AGUILERA
TRADUCTOR E INTERPRETE OFICIAL
RES. 718 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA

773

CERTIFICADA

5. En Harrisburg, Pennsylvania.
6. Hoy 11 de Abril, 2006
7. Por el Pedro A. Cortés, Secretario de la Mancomunidad de Pensilvania
8. No. **200614443**
9. Sello (Sello de Oblea Dorado de la Secretaría de la Mancomunidad de Pensilvania)
10. Firma (Firmado)
Pedro A. Cortés

(En español, Sello Notarial certificando la autenticidad de la fotocopia)

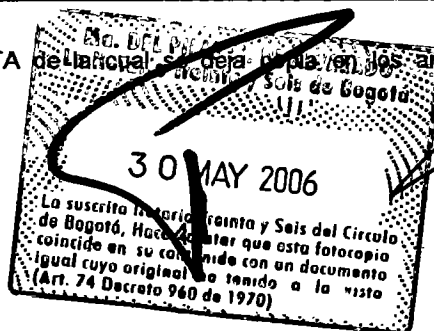
APOSTILLA

(Convenio de la Haya de Octubre 5 de 1961)

1. País: Estados Unidos de América
Este documento público
 2. Ha sido firmado por CHARLENE RICE
 3. Actuando en calidad de Notario Público
 4. Lleva el sello/estampilla de Charlene Rice, Notario Público, Condado de Filadelfia, Mancomunidad de Pennsylvania
- CERTIFICADA**
5. En Harrisburg, Pennsylvania.
 6. Hoy 11 de Abril, 2006
 7. Por el Pedro A. Cortés, Secretario de la Mancomunidad de Pensilvania
 8. No. **200614442**
 9. Sello (Sello de Oblea Dorado de la Secretaría de la Mancomunidad de Pensilvania)
 10. Firma (Firmado)
Pedro A. Cortés

(En español, Sello Notarial certificando la autenticidad de la fotocopia)

ES TRADUCCIÓN FIEL Y COMPLETA de la original, a la cual me remito.
Bogotá, Mayo 30, 2006.



TRADUCCION OFICIAL No. 3021
JUAN PABLO PIEDRAHITA AGUILERA
TRADUCTOR E INTERPRETE OFICIAL
RES. 718 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA

779

APOSTILLE

(Convention de La Haye du 5 octobre 1961)

1. Country : United States Of America

2. This public document has been signed by JOANNA FRANKLIN RANGE

3. acting in the capacity of NOTARY PUBLIC

4. bears the seal/stamp JOANNA FRANKLIN RANGE, NOTARY PUBLIC, CHESTER COUNTY, COMMONWEALTH OF PENNSYLVANIA

Certified

5. at Harrisburg, Pennsylvania

6. The 11th day of April, 2006

7. by Pedro A. Cortés, Secretary of the Commonwealth of Pennsylvania

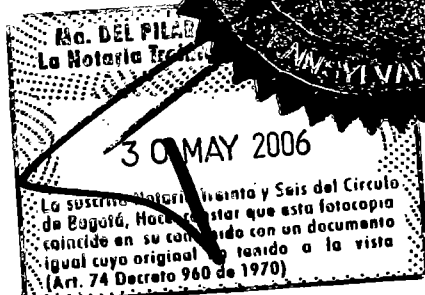
8. No: 200614443

9. Seal/Stamp

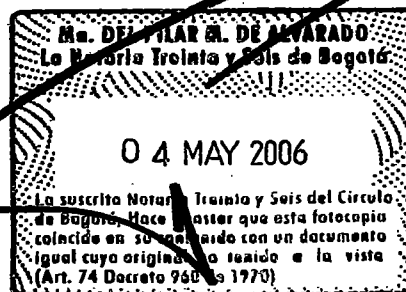
10. Signature

Pedro A. Cortés

Pedro A. Cortés



TRADUCCION OFICIAL No.
JUAN PABLO PIEDRAHITA AGUIRERA
TRADUCTOR E INTERPRETE OFICIAL
Res. 718 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA



120

APOSTILLE

(Convention de La Haye du 5 octobre 1961)

Country : United States Of America

2. This public document has been signed by **CHARLENE RICE**

3. acting in the capacity of **NOTARY PUBLIC**

4. bears the seal/stamp **CHARLENE RICE, NOTARY PUBLIC, PHILADELPHIA COUNTY, COMMONWEALTH OF PENNSYLVANIA**

Certified

5. at Harrisburg, Pennsylvania

6. The 11th day of April, 2006

7. by **Pedro A. Cortés, Secretary of the Commonwealth of Pennsylvania**

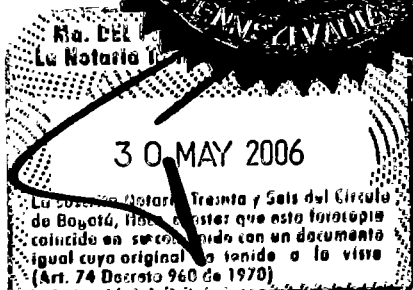
8. No : 200614442

9. Seal/Stamp

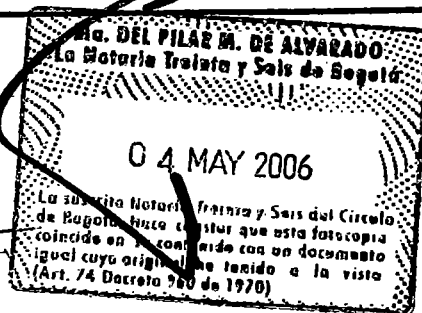
10. Signature

Pedro A. Cortés

Pedro A. Cortés



TRADUCCION OFICIAL NO. 087
JUAN PABLO PIEDRITA AGUILERA
TRADUCTOR E INTERPRETE OFICIAL
RES. 718 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA



Clarke, Modet & Co. Colombia

E-MAIL: info@clarkemodet.com.co
SANTAFÉ DE BOGOTÁ, A.A. 92397 COLOMBIA

727

CESION

El (la) abajo firmante (En adelante EL CEDENTE)

en su carácter de inventor /diseñador

con domicilio en:

por el presente documento declara que cede todos y cada uno de los derechos que le corresponden o puedan corresponderle sobre la siguiente invención, modelo de utilidad, diseño industrial

a:

con domicilio en

TRADUCCION OFICIAL No. _____
JUAN PABLO MEDARITA AGUILERA
TRADUCTOR E INTERPRETE OFICIAL
RES. 718 DE MAYO 2003
DEL MIN. INTERIOR Y DE JUSTICIA

En prueba de la mutua aceptación de esta cesión ambas partes CEDENTE y CESIONARIO firman el presente documento.

Dado y firmado en
A los _____ Días de _____ De _____

ASSIGNMENT

The undersigned (Hereinafter THE ASSIGNOR)

Anthony M. Lowman
Michele S. Marcolongo
Alastair J. T. Clemow

Inventor /designor of

THERMOGELLING POLYMER BLENDS
FOR BIOMATERIAL APPLICATIONS

domiciled at, respectively,

Wallingford, Pennsylvania, U.S.A.
Aston, Pennsylvania, U.S.A.
Princeton, New Jersey, U.S.A.

do hereby declares that it assigns all and each of his rights and privileges on the following invention, industrial design, utility model

THERMOGELLING POLYMER BLENDS
FOR BIOMATERIAL APPLICATIONS

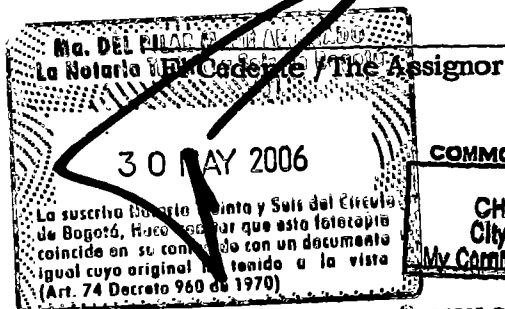
To DREXEL UNIVERSITY and
GELIFEX, INC.

with domicile in, respectively,

Pennsylvania, U.S.A. and
Pennsylvania, U.S.A.

As a proof of the mutual acceptance of this assignment, both parties ASSIGNOR and ASSIGNEE sign the present document.

Granted and signed at
on this 8th day of February of 2006

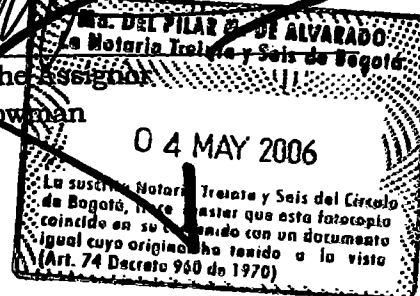


COMMONWEALTH OF PENNSYLVANIA

NOTARIAL SEAL
CHARLENE RICE, Notary Public
City of Philadelphia, Phila. County
My Commission Expires December 30, 2009

Sworn to and subscribed before me
this 8th day of February 2006

El Cedente /The Assignor
Anthony M. Lowman

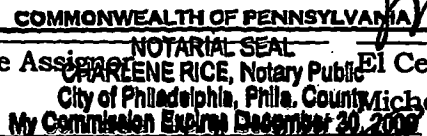


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A los Días de De

Granted and signed at
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El Cedente /The Assignor El Cedente /The Assignor



CHARLENE RICE, Notary Public
City of Philadelphia, Phila. County
My Commission Expires December 30, 2009

Michelle S. Marcolongo

Dado y firmado en
A los 22nd Días de Feb. De 2006

Granted and signed at
on this 22nd day of February of 2006

El Cedente /The Assignor
MARIE S. PETER
NOTARY PUBLIC NEW JERSEY
My Commission Expires June 20, 2006

El Cedente /The Assignor
Alastair J. T. Clemow

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A los Días de De
COMMONWEALTH OF PENNSYLVANIA
NOTARIAL SEAL
CHARLENE RICE, Notary Public
City of Philadelphia, Phila. County
My Commission Expires December 30, 2009

signed at
on this 8th day of February of 2006

DREXEL UNIVERSITY

BY: Robert B. McBreth
El Cesionario/The Assignee
Name: Robert B. McBreth
Title: Associate Vice Provost

El Cesionario/The Assignee
Sworn and subscribed before me
this 8th day of Feb. 2006
Charlene Rice

Firmado en
A los Días de De

signed at
on this 15th day of February of 2006

GELIFEX, INC.

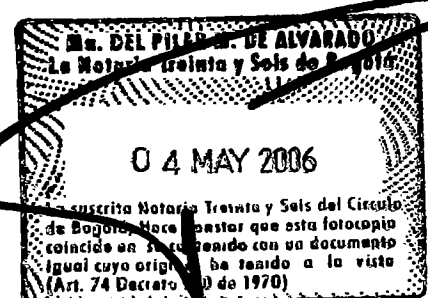
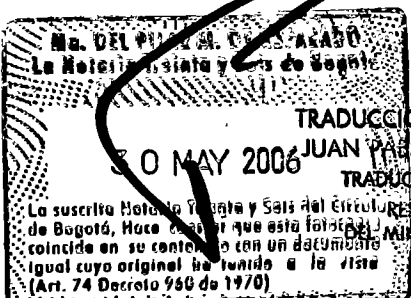
BY: Troy Sihl
El Cesionario/The Assignee
Name: Troy Sihl
Title: Patent Counsel

El Cesionario/The Assignee

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Joanna Franklin Range, Notary Public
West Goshen Twp., Chester County
My Commission Expires August 20, 2009
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Joanna Franklin Range



PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:
MITCHELL W. SHAPIRO
MILES & STOCKBRIDGE P.C.
1751 PINNACLE DRIVE, SUITE 500
MCLEAN, VA 22102-3833

PCT

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL SEARCH REPORT AND
THE WRITTEN OPINION OF THE INTERNATIONAL
SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Date of mailing
(day/month/year) **17 NOV 2005**

Applicant's or agent's file reference
8932-942-228

FOR FURTHER ACTION See paragraphs 1 and 4 below

International application No.
PCT/US04/13343

International filing date
(day/month/year) 30 April 2004 (30.04.2004)

Applicant
DREXEL UNIVERSITY

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

Filing of amendments and statement under Article 19:

The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes
1211 Geneva 20, Switzerland, Facsimile No.: (41-22) 338.82.70.

For more detailed instructions, see the notes on the accompanying sheet.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

- ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.
☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

Shortly after the expiration of 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.

The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. These comments would also be made available to the public but not before the expiration of 30 months from the priority date.

Within 19 months from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later); otherwise, the applicant must, within 20 months from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

In respect of other designated Offices, the time limit of 30 months (or later) will apply even if no demand is filed within 19 months.

See the Annex to Form PCT/IB/301 and, for details about the applicable time limits, Office by Office, see the *PCT Applicant's Guide*, Volume II, National Chapters and the WIPO Internet site.

Name and mailing address of the ISA/ US
Mail Stop PCT, Attn: ISA/US
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
Facsimile No. (703) 305-3230

Authorized officer

D. L. Jones

Telephone No. (703) 308-1235

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 8932-942-228	FOR FURTHER ACTION see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. PCT/US04/13343	International filing date (day/month/year) 30 April 2004 (30.04.2004)	(Earliest) Priority Date (day/month/year) 30 April 2003 (30.04.2003)
Applicant DREXEL UNIVERSITY		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 2 sheets.



It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the Report

a. With regard to the language, the international search was carried out on the basis of:



the international application in the language in which it was filed.



a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

b. ☐ With regard to any nucleotide and/or amino acid sequence disclosed in the international application, see Box No. I.

2. ☐ Certain claims were found unsearchable (See Box No. II)

3. ☐ Unity of invention is lacking (See Box No. III)

4. With regard to the title,



the text is approved as submitted by the applicant.



the text has been established by this Authority to read as follows:

5. With regard to the abstract,



the text is approved as submitted by the applicant.



the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the drawings,

a. the figure of the drawings to be published with the abstract is Figure No. _____



as suggested by the applicant.



as selected by this Authority, because the applicant failed to suggest a figure.



as selected by this Authority, because this figure better characterizes the invention.



b. none of the figures is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/13343

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : A61K 51/00; A61M 36/14

US CL : 424/1.65

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 424/1.65

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
caplus

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KANEKO et al. Synthesis and swelling - deswelling kinetics of poly(N-isopropylacrylamide) hydrogels grafted with LCST modulated polymers. J. Biomater. Sci. Polymer Edu., 1999, Vol. 10, No. 11, pp. 1079-1091, especially, page 1079, abstract; and page 1081, 'Methods';	1-4, 6, and 7
A		5, 8, 9, and 12-20

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

25 October 2005 (25.10.2005)

Date of mailing of the international search report

17 NOV 2005

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Facsimile No. (703) 305-3230

Authorized officer

D. E. Jones

Telephone No. (703) 308-1235

1. Name of the person or organization	2. Address of the person or organization
3. Date of birth or date of establishment	4. Place of birth or place of establishment
5. Date of death or date of liquidation	6. Place of death or place of liquidation
7. Date of marriage or date of incorporation	8. Place of marriage or place of incorporation
9. Date of divorce or date of dissolution	10. Place of divorce or place of dissolution
11. Date of remarriage or date of re-incorporation	12. Place of remarriage or place of re-incorporation
13. Date of remarriage or date of re-incorporation	14. Place of remarriage or place of re-incorporation
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31. Date of remarriage or date of re-incorporation	32. Place of remarriage or place of re-incorporation
33. Date of remarriage or date of re-incorporation	34. Place of remarriage or place of re-incorporation

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NOTES TO FORM PCT/ISA/220 (continued)

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

- (i) the claim is unchanged;
- (ii) the claim is cancelled;
- (iii) the claim is new;
- (iv) the claim replaces one or more claims as filed;
- (v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."
2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."
3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."
4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under Article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international application is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments and any accompanying statement, under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the time of filing the amendments (and any statement) with the International Bureau, also file with the International Preliminary Examining Authority a copy of such amendments (and of any statement) and, where required, a translation of such amendments for the procedure before that Authority (see Rules 55.3(a) and 62.2, first sentence). For further information, see the Notes to the demand form (PCT/IPEA/401).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see the *PCT Applicant's Guide*, Volume II.

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Synthesis and swelling–deswelling kinetics of poly(*N*-isopropylacrylamide) hydrogels grafted with LCST modulated polymers

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Received 27 January 1999; accepted 9 June 1999

Abstract—Two types of thermo-responsive hydrogels are synthesized to obtain comb-type grafted gels with different lower critical solution temperatures (LCSTs) between graft chains and cross-linked backbone networks: these are poly(*N*-isopropylacrylamide) (PIPAAm) cross-linked hydrogels grafted with poly(*N*-isopropylacrylamide-*co*-*N,N*-dimethylacrylamide) (poly(IPAAm-*co*-DMAAm)) maintaining a freely mobile end and poly(IPAAm-*co*-DMAAm) cross-linked hydrogels grafted with PIPAAm chains. The effect of graft chain hydrophilic/hydrophobic balance as well as its mobility on deswelling kinetics of these grafted gels are investigated through the polymer LCST modulation and external temperature changes. The deswelling rate of poly(IPAAm-*co*-DMAAm)-grafted PIPAAm gel increases with increasing in temperature. This gel shows a discontinuous increase of the deswelling rate when the temperature is applied from below to above the graft chain LCST (37°C). The deswelling rate of PIPAAm-grafted poly(IPAAm-*co*-DMAAm) gel increases continuously when the temperature is applied from below to above the graft chain LCST (31°C). Due to the strong hydrophilicity of backbone network, the hydrophobic aggregation force weak. In contrast to the graft-type gels, normal-type poly(IPAAm-*co*-DMAAm) cross-linked gel without graft chains demonstrates the discontinuous decrease for the deswelling rate when the temperature is applied from below to above the polymer LCST (36°C), entrapping water inside the gel due to the formation of an impermeable dense skin layer at the gel surface. These gel deswelling mechanisms are discussed in terms of gel structures.

Key words: Comb-type grafted gel; LCST modulated polymers; deswelling kinetics; polymer aggregation; surface skin layer.

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INTRODUCTION

Stimuli-responsive polymers have been recently investigated as advanced biomedical technologies including 'on-off' switching materials [1], drug delivery systems [2–5], artificial muscles [6–9], and mass separations [10, 11]. We have been studying thermo-responsive poly(*N*-isopropylacrylamide) (PIPAAm) cross-linked hydrogels as drug release regulating devices which respond to temperature changes [1–3]. When a cross-linked PIPAAm gel is immersed in water above its lower critical solution temperature (LCST 32°C), deswelling immediately starts at the gel surface due to the freely mobile nature of polymer chains at the surface and the collective diffusion of the cross-linked polymer network in water [12–14]. The gel thus forms a dense polymer skin layer at the surface. This prevents permeability, entrapping water within the gel. This skin layer leads to a very slow deswelling of the bulk polymer network. We have investigated thermally-induced 'on-off' drug release regulation by utilizing the formation of this skin layer impermeable to drug molecules as well as water [1, 2, 12].

To promote new hydrogel applications, such as artificial muscles and rapidly acting actuators, swelling–deswelling of the bulk gel and its surface has to be accelerated. We have introduced a novel deswelling mechanism rather than collective diffusion to enhance the swelling–deswelling rate of thermo-responsive hydrogels [15–18] using a PIPAAm cross-linked gel containing PIPAAm graft chains with a freely mobile end. PIPAAm molecules in aqueous solution exhibit a rapid and reversible hydration–dehydration change in response to small temperature changes around its LCST [19, 20]. By utilizing this unique characteristic of PIPAAm, we have achieved temperature-responsive rapidly acting actuators [17, 21], intelligent surfaces [22, 23] and polymeric micelles [24]. In the PIPAAm-grafted gel, graft chains undergo rapid dehydration in response to small temperature increases due to the nature of freely mobile PIPAAm grafts. As graft chains become hydrophobic, the LCST of the backbone network might decrease due to hydrophobic sites created within the polymer network, enhancing hydrophobic aggregation [2, 25] and water is rapidly released from the gel. Compared with the conventional PIPAAm gel without graft chains, size-independent and rapid gel swelling–deswelling kinetics is obtained with comb-type grafted gels [18]. This deswelling mechanism is totally different from the gels with macropore structures for rapid swelling–deswelling of PIPAAm [26–28], poly(vinyl alcohol) gel [29] and poly(vinyl methyl ether) gels [7] or gels with hydrophilic moieties such as acrylic acid [21, 30, 31] in the PIPAAm network to reduce the hydrophobic aggregation for faster deswelling without skin layer formation.

In the present research, we investigate the effects of graft chain LCST as well as its mobility on equilibrium swelling properties and swelling–deswelling kinetics using two different types of grafted gels by polymer LCST modulation. The first gel type is IPAAm copolymerized with hydrophilic *N,N*-dimethylacrylamide (DMAAm) (poly(IPAAm-*co*-DMAAm)) is introduced as graft chains (LCST 37°C) in the cross-linked PIPAAm homopolymer network. The second one is PIPAAm

homopolymer is introduced as a graft chain in the cross-linked copolymer network composed of IPAAm and DMAAm. Changes in deswelling rate by the introduction of graft chains with different LCSTs from backbone networks are investigated in comparison with normal-type PIPAAm and poly(IPAAm-co-DMAAm) cross-linked gels without graft chains. The normal-type gels form the dense surface skin layers impermeable to water during the deswelling changes. In contrast, rapid deswelling without skin layer formation was observed for graft type gels. These gel deswelling mechanisms are discussed in terms of the gel structures and external temperature change.

METHODS

Materials

N-Isopropylacrylamide (Kojin Co., Tokyo, Japan) was purified by recrystallization from *n*-hexane [20]. Cysteamine hydrochloride (Wako Pure Chemical Industry Co., Osaka, Japan) was purified by recrystallization from methanol. Benzoyl peroxide (BPO) was generously provided from NOF (Tokyo, Japan) and used as-received. Triethylamine (Kanto Chemical Co., Tokyo, Japan) was distilled at 90°C under atmospheric pressure. *N,N*-Dimethylacrylamide (DMAAm; Kanto Chemical Co.) was distilled and obtained as a fraction boiling at 73°C/16 mmHg. Tetrahydrofuran (THF; Kanto Chemical Co.) was distilled at 69°C under atmospheric pressure. *N,N*-Dimethylformamide (DMF; Kanto Chemical Co.) was purified by distillation under reduced pressure and obtained as a fraction boiling at 48°C/17 mmHg. Acryloyl chloride (Tokyo Kasei Kogyo Co., Tokyo, Japan), *t*-butyl catechol (Wako Pure Chemical Industry Co.), and diethyl ether (Kanto Chemical Co.) were all used as-received. *N,N,N',N'*-Tetramethylethylenediamine (TEMED), ammonium persulfate (APS) and *N,N'*-methylenebisacrylamide (MBAAm) were purchased from Kanto Chemical Co. and used as-received. Chloroform (Wako Pure Chemical Industry Co.), chloroform-*d* (Aldrich Chemical Co.) and HPLC grade DMF (Wako Pure Chemical Industry Co.) as a GPC eluent were used as-received.

Macromonomer preparation

IPAAm and DMAAm monomers in feed composition of 70:30 mol% were dissolved in DMF. After addition of 5 mmol l⁻¹ BPO as a polymerization initiator and cysteamine hydrochloride (molar ratio to monomer: 0.02) as a chain transfer agent, the solution was degassed by repeated freeze-thaw cycles, and polymerization was then carried out at 70°C for 3 h. The reactant was poured into diethyl ether to precipitate polymers. The polymer product with amino groups at one end was then dialyzed in pure water using a dialysis tube (Spectra/Por CE, MWCO 500) for 4 days, changing the water every day. Poly(IPAAm-co-DMAAm) was freeze-dried from aqueous solution. IPAAm homopolymer (IPAAm; 100%) with an amino terminal was also synthesized by the same method.

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A macromonomer was then prepared by reacting the terminal amino groups with acryloyl chloride. The synthesized polymer was dissolved in THF with *t*-butyl catechol as a polymerization inhibitor and a large amount of triethylamine as a scavenger for hydrochloric acid. After dropwise addition of excess amount of acryloyl chloride at 0°C, the solution was kept at 40°C for 1 day with vigorous stirring. Precipitated triethylamine hydrochloride was removed by vacuum filtration using celite as a filter. The filtrate was then concentrated by evaporating THF. The macromonomer was recovered as precipitates from diethyl ether. After the dialysis against water for 3 days, the macromonomer with a terminal polymerizable group was freeze dried from aqueous solution.

Macromonomer analysis

The end group of the macromonomer was analyzed by ¹H-NMR measurements. The polymers were dissolved in chloroform-*d*. Chemical shifts for a ¹H attributing terminal double bond were measured using 400 MHz NMR equipment (Bruker AM-400FT-NMR, Rheinstetten, Germany). The molecular weight of the prepared macromonomer was determined by gel permeation chromatography (GPC; TOSOH column types: GMPW_{HR} × 2, Tokyo, Japan) using DMF containing 10 mM LiCl as eluent at a flow rate of 1.0 ml min⁻¹ at 40°C and detected on a refractive index (RI) detector (TOSOH RI-8022, Tokyo, Japan). A calibration curve for molecular weight determination was made using known molecular weight poly(ethylene oxide) (PEO) standards. The macromonomer LCST was determined by transmittance changes ($\lambda = 500$ nm) of 0.4 wt% polymer aqueous solution with a temperature increase of 0.1°C min⁻¹ using UV/VIS spectrophotometer (V-530, JASCO, Tokyo, Japan).

Synthesis of cross-linked gels

Comb-type grafted gel was synthesized according to previous reports [15, 16]. Briefly, IPAAm monomer, DMAAm monomer, and macromonomer at various ratios (total weight 1.56 g), MBAAm (0.0266 g, 1.68 wt% to monomer) as a cross-linker, and TEMED (48 μ l) as an accelerator were dissolved in 10 ml of distilled water. Dry nitrogen gas was bubbled into solution for 10 min to remove dissolved oxygen. After addition of 8 mg APS as an initiator, the solution was injected between two Mylar sheets separated by a Teflon gasket (1.0 mm thick) and backed with glass plates. Polymerization was carried out at 15°C for 1 day. The formed graft-type gel membrane was immersed in pure water for 7 days at room temperature with water changed every day to remove unreacted compounds. The swollen gel membrane was cut into disks (15 mm diameter) using a cork borer at 25°C and dried under ambient conditions for 1 day followed by thorough drying under vacuum for 3 days at room temperature. Compositions of DMAAm to IPAAm within the hydrogels were determined by 400 MHz ¹H-NMR measurements. As a control, normal-type PIPAAm gel and poly(IPAAm-*co*-DMAAm) gel without

Table 1.
Preparation and characterization of hydrogels^a

Sample	Feed composition					Synthesized gel	
	DMAAm (mol%)	IPAAm (g)	DMAAm (g)	Macromonomer (g)	MBAAm (g)	Conversion (%)	DMAAm ^b (mol%)
IP-NG	0.0	1.56	0.000	0.000	0.0266	85	0.0
ID-NG	4.0	1.52	0.0553	0.000	0.0266	86	4.5
ID-GG	9.2	1.09	0.000	0.468	0.0266	67	4.6
IP-GG	9.2	0.948	0.128	0.468	0.0266	50	5.1

^a Reaction temperature: 15°C, reaction time: 24 h, solvent: distilled water (10 ml), TEMED 48 μ l, APS 3 mg.

^b Determined by NMR.

macromonomers were synthesized and purified by the same method as described above. The results of the polymerization are summarized in Table 1.

Swelling equilibria for hydrogels

Equilibrium swelling ratio (W_{H_2O}/W_p) of each gel type was defined as the weight of absorbed water (W_{H_2O}) per weight of dried gel (W_p). Equilibrium swelling weights for the gels in water at various temperatures were measured gravimetrically after wiping excess water from the gel surface using filter paper. The pre-weighed dry gels were first equilibrated at a higher temperature for 3 days in Dulbecco's phosphate buffered saline (PBS, pH 7.4) composed of 0.137 M NaCl, 2.68 mM KCl, 8.10 mM Na_2HPO_4 , and 1.47 mM KH_2PO_4 . After determining the gel mass, the temperature was lowered, and the gels were equilibrated to reach swollen conditions at this temperature for 3 days. This process was repeated until the temperature reached to 10°C. The temperature of the water bath was controlled using thermostated water bath (LAUDA-RM20, Messgeratewerk, Germany) with a deviation of $\pm 0.1^\circ\text{C}$. The experimental plots were averages of three samples. Error bars are smaller than each plot.

Swelling-deswelling kinetics of hydrogels

Disk shaped gels were all first equilibrated in PBS (pH 7.4) at a predetermined temperature. The gels were then quickly transferred into PBS at different temperatures. At specific time intervals these gels were taken out of PBS and weighed after removing excess water from the gel surface. The swelling and deswelling kinetics were defined as temporal weight changes for the gels. The gel initial deswelling rate was calculated from weight decreases over the first 10 min. The experimental plots were averages of three samples. Error bars are smaller than each plot.

RESULTS AND DISCUSSION

Macromonomer preparation and its analysis

From H-NMR measurements, the chemical shift at 5.5–6.5 ppm arising from vinyl protons was observed after the substitution reaction for the end amino groups of polymers to polymerizable vinyl groups. The composition of synthesized poly(IPAAm-*co*-DMAAm) macromonomer was determined to be 37 mol% of DMAAm by NMR measurement. The weight-averaged molecular weights (M_w) of synthesized PIPAAm macromonomer and poly(IPAAm-*co*-DMAAm) macromonomer were determined to be 33000 and 28000 by GPC using PEO as standards, respectively. By measuring optical transmittance changes ($\lambda = 500$ nm) of polymer solution (0.4 wt%) with gradual temperature increase, LCSTs of these polymers were determined to be 31°C for PIPAAm macromonomer and 37°C for poly(IPAAm-*co*-DMAAm) macromonomer, respectively.

Hydrogel synthesis

The weight conversions from monomers to synthesized gels are listed in Table 1. They were determined to be 50–67 wt% for the graft-type gels and 85–86 wt% for normal-type gels, respectively. DMAAm contents in synthesized gels were determined to be 4.5 mol% for the normal-type poly(IPAAm-*co*-DMAAm) gel (ID-NG), 4.6 mol% for the poly(IPAAm-*co*-DMAAm)-grafted PIPAAm gel (ID-GG), and 5.1 mol% for the PIPAAm-grafted poly(IPAAm-*co*-DMAAm) gel (IP-GG) by NMR measurements, respectively. These gels contained almost same amount of DMAAm. Structures for these gels and the normal-type PIPAAm gel (IP-NG) are schematically illustrated in Fig. 1.

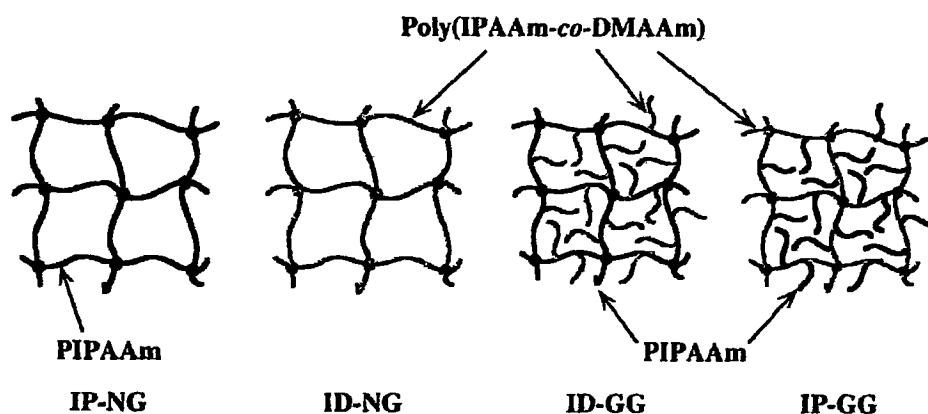


Figure 1. Schematic illustration of structures for normal-type PIPAAm gel (IP-NG), normal-type poly(IPAAm-*co*-DMAAm) gel (ID-NG), poly(IPAAm-*co*-DMAAm)-grafted PIPAAm gel (ID-GG), and PIPAAm-grafted poly(IPAAm-*co*-DMAAm) gel (IP-GG). Black lines and gray lines demonstrate PIPAAm and poly(IPAAm-*co*-DMAAm) chains, respectively.

Equilibrium swelling measurements

Figure 2 shows equilibrium swelling ratios for IP-NG, ID-NG, ID-GG, and IP-GG in PBS (pH 7.4). All gels were swollen at lower temperatures and shrunken above phase transition temperature (T_p). All the gels showed transparency at the equilibrium swollen and shrunken states in Fig. 2, which is demonstrating polymer aggregation larger than visible light wave length not formed in the network. T_p for IP-NG was observed around 31°C. The T_p s for ID-NG, ID-GG, and IP-GG were observed around 36, 37, and 38°C, respectively. The T_p and equilibrium swelling ratio at lower temperature increase with the introduction of hydrophilic DMAAm as a comonomer (ID-NG) and poly(IPAAm-*co*-DMAAm) graft chains (ID-GG). In these gels, PIPAAm sequences of backbone networks were divided into multiple-points by DMAAm comonomer and poly(IPAAm-*co*-DMAAm) graft chains.

We have already investigated the T_p shift and equilibrium swelling ratios of PIPAAm-grafted PIPAAm cross-linked gels [16, 17] and PEO-grafted PIPAAm gel (poly(IPAAm-*g*-PEO)) with increasing the amount of PEO graft chains [21]. The T_p of PIPAAm-grafted PIPAAm gel did not shift compared with the normal-type PIPAAm gel (32°C). This is because both graft chains and backbone networks are composed of PIPAAm homopolymer. In contrast, poly(IPAAm-*g*-PEO) gels demonstrate increasing T_p s than IPAAm homopolymer gels by introducing hydrophilic PEO grafts. However, the graft structure of poly(IPAAm-*g*-PEO) gels kept high thermosensitivity as is shown in the abrupt volume phase transitions when compared with the equilibrium swelling ratio of acrylic acid copolymerized gels (poly(IPAAm-*co*-AAc)). This is because PEO graft chains unlike AAc divides PIPAAm sequences without interfering with PIPAAm aggregation.

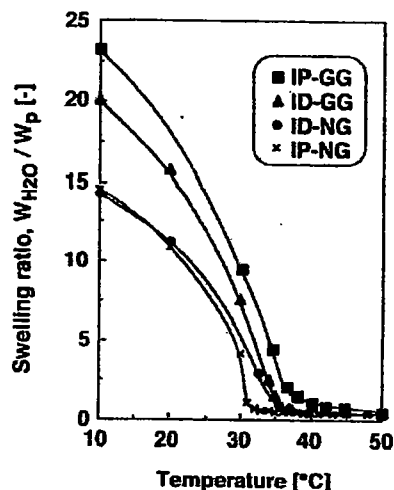


Figure 2. Equilibrium swelling ratio of IP-NG, ID-NG, ID-GG, and IP-GG hydrogels as a function of temperature in PBS (pH 7.4).

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Similarly to poly(IPAAm-co-AAc) gels, hydrophilic DMAAm units interfere with the hydrophobic aggregation of PIPAAm backbone sequences of ID-NG, and so higher T_p than IP-NG was observed. Compared with ID-NG gel, the ID-GG gel has the same PIPAAm homopolymer backbone network with IP-NG. Hydrated poly(IPAAm-co-DMAAm) graft chains with higher LCST (37°C) increase the T_p of the gel as is observed in poly(IPAAm-g-PEO) gels. ID-GG demonstrated sharp volume phase transition compared with ID-NG, although these gels have almost the same DMAAm amount.

In the case of IP-GG gel, a large magnitude of T_p shift (7°C) compared to ID-NG (5°C) from IP-NG was observed. The backbone network of IP-GG is composed of poly(IPAAm-co-DMAAm). Although almost the same amount of DMAAm was introduced in both IP-GG and ID-NG, the distance between cross-linking points of graft-type gel was relatively shortened owing to the existence of graft chains compared with normal-type gels (70% length of normal-type gel calculated from feed composition). Therefore, a larger amount of DMAAm was accumulated in the IP-GG backbone network compared with ID-NG. The LCST of IP-GG backbone network increasing with increasing hydrophilicity of polymer backbone network, which also affects the increased T_p rather than that of ID-NG.

The equilibrium swelling ratios demonstrated almost the same value for IP-NG and ID-NG at lower temperature around 10°C. In contrast, ID-GG and IP-GG showed higher swelling ratios than ID-NG and IP-NG below T_p s. The IP-GG demonstrated the largest swelling ratio in these gels. The swelling ratio became higher with the existence of graft chains. The mobility of graft chains were enhanced due to the freely mobile ends in the chains. This leads to the increased exclusion volume of graft chains, resulting in higher swelling ratio of the comb-type grafted hydrogels as was previously discussed in PIPAAm-grafted PIPAAm gels [15–17] and poly(IPAAm-g-PEO) gels [18]. It may also be plausible that decreased monomer conversion to polymer gels during gel synthesis for graft type gels causes increased swelling ratios at lower temperatures.

Deswelling kinetics and mechanisms of hydrogels

Figures 3–5 show the deswelling kinetics of ID-NG, ID-GG and IP-GG after a temperature jump from equilibrium swelling at 10°C to below and above T_p , respectively. Cross (x) plots and open (o) plots demonstrate the deswelling kinetics at temperatures below T_p . Closed plots demonstrate the deswelling kinetics above T_p for each gel. A remarkable difference is observed between the normal-type ID-NG gel (Fig. 3) and the graft-type gels (Figs 4 and 5). The deswelling change of ID-NG became faster with increasing temperature up to 36°C, although the deswelling change became slower above 38°C. The swelling ratio of the gels decreased exponentially below T_p . The ID-NG gel deswelling change became slower after the initial fast deswelling change over the T_p , most probably due to the skin layer formation impermeable to water molecules. In contrast, the deswelling kinetics of graft-type gels became faster with increasing temperature.

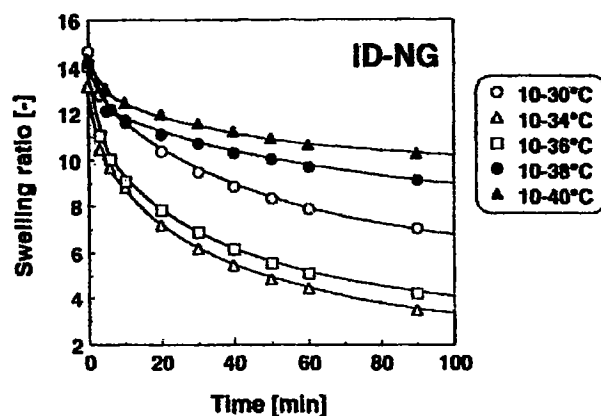


Figure 3. Deswelling kinetics of ID-NG hydrogels from equilibrium swelling condition at 10°C in PBS (pH 7.4) (initial gel dimension: 1.0 mm thick and 15 mm diameter).

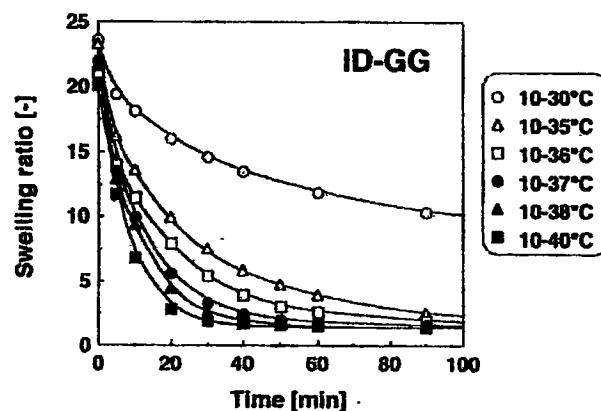


Figure 4. Deswelling kinetics of ID-GG hydrogels from equilibrium swelling condition at 10°C in PBS (pH 7.4) (initial gel dimension: 1.0 mm thick and 15 mm diameter).

The deswelling kinetics of ID-GG and IP-GG demonstrated exponential weight decreases at each temperature.

Figure 6 shows the relationship between an initial gel deswelling rate and deswelling temperature for three types of gels (ID-NG, ID-GG, and IP-GG). The changes in deswelling rate to temperature changes are summarized as follows:

- (1) The ID-NG gel demonstrated discontinuous decreases in deswelling rates above the polymer LCST (in this case, hydrogel T_p), indicative of water entrapment within the gel during the gel deswelling changes above its T_p .
- (2) The ID-GG demonstrated gradual increase of deswelling rate with increasing gel deswelling temperature. The slope of this line was larger than that of normal-type ID-NG. This gel showed the discontinuous increase in deswelling rate above the LCST of grafted chains (37°C).

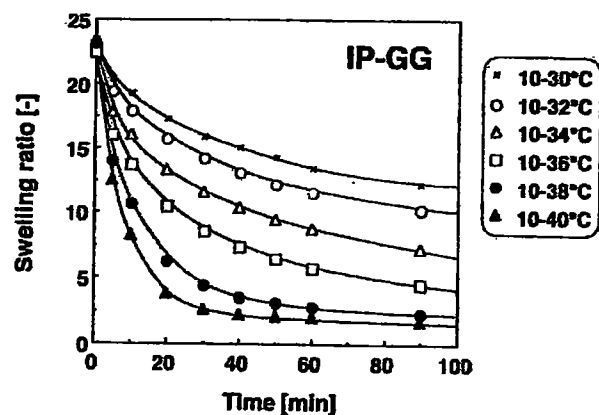


Figure 5. Deswelling kinetics of IP-GG hydrogels from equilibrium swelling condition at 10°C in PBS (pH 7.4) (initial gel dimension: 1.0 mm thick and 15 mm diameter).

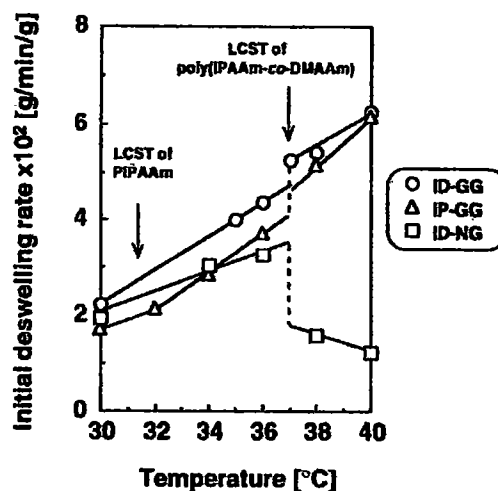


Figure 6. Changes in initial deswelling rate of hydrogels as a function of deswelling temperature.

- (3) The IP-GG demonstrated the slowest deswelling rate in the three types of gels below the graft chain LCST (31°C). The deswelling rate increased continuously at temperature range of 32–37°C. The slope of the line was the largest in three gel types. The gel deswelling rate was increased discontinuously around 37°C.

From these results, the changes in deswelling mechanism of the gels are discussed according to the gel structure and the external temperature changes. The transparent ID-NG at 10°C became opaque as the temperature was increased over T_p , indicating a formation of a heterogeneous structure of an aggregated polymer network. The slow deswelling change of ID-NG was attributed to this surface skin layer formation. In previous papers [2, 12, 32, 33], we have systematically investigated the effect of skin layer formation on the deswelling kinetics of PIPAAm hydrogels by controlling temperature and gel chemical compositions. Below the gel T_p , gel

deswelling kinetics are dominated by the collective diffusion mechanism. Thus, the gels decreased their swelling ratios exponentially without the formation of skin layer at the gel surface. By contrast, at temperatures above T_p , the surface of the gel immediately dehydrates to form the skin layer which blocks water flow out of the gel. The hydrodynamic internal pressure then gradually increases and water accumulates near the surface of the gel due to increasing internal pressure [12]. When the internal pressure becomes too large, water is convectionally transported from the gel, causing gradual gel deswelling changes.

The acceleration of the deswelling rate of ID-GG above the backbone LCST (31°C) might be due to the water release channels formed in the network. We have already discussed the effect of hydrophilic graft chains on the rapid gel deswelling changes using poly(IPAAm-*g*-PEO) gels [21]. The water releasing molecular channels are formed in the network by PEO grafted chains, and then the water is rapidly squeezed out of the gel due to the strong hydrophobic aggregation operating between the PIPAAm backbone network. It may also be plausible that decreased monomer conversion to polymer gels during gel synthesis for graft type gels can cause fast deswelling changes.

CONCLUSIONS

We have investigated the deswelling mechanisms of comb-type grafted hydrogels with LCST modulated polymers in direct observation of the gel deswelling kinetics with temperature increases.

- (1) The normal-type gel (ID-NG) without graft chains demonstrated slow deswelling kinetics with temperature increase above the polymer LCST due to the formation of surface impermeable skin layers.
- (2) The ID-GG demonstrated diffusion-mediated deswelling kinetics below the backbone polymer LCST. The gel deswelling rate was accelerated with temperature increase above the backbone polymer LCST due to the formation of water release channels with hydrated graft chains. The discontinuous and rapid deswelling change was observed above the graft chain LCST due to the formation of hydrophobic aggregates with dehydrated graft chains.
- (3) The IP-GG demonstrated diffusion-mediated deswelling kinetics below the graft chain LCST. The gel deswelling rate was accelerated with temperature increase above the graft chain LCST. The hydrophilic DMAAm of backbone network disturbed the hydrophobic attraction of dehydrated grafted chains and increase of backbone LCST, thus the gel deswelling kinetics were slower than ID-GG at the same temperature change. In contrast, the rapid deswelling change occurred with temperature increase above the LCST of polymer backbone network.

By utilizing the hydrophobic aggregation of grafted LCST polymer chains attributing to the polymer elastic forces, rapid gel deswelling change was obtained.

Rapid temperature response of graft-type gels might be utilized for artificial muscle, actuators, or biomaterials for drug delivery systems. As for drug delivery systems, the fast gel deswelling change might induce the rapid drug release for an accumulation of drug molecules at disease sites (targeting) by applying small temperature changes.

Acknowledgements

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