Preparation and In Vitro Evaluation of New pH-Sensitive Hydrogel Beads for Oral Delivery of Protein Drugs

El-Sherbiny, IM (El-Sherbiny, I. M.)[1,2]; Abdel-Bary, EM (Abdel-Bary, E. M.)[2]; Harding, DRK (Harding, D. R. K.)[1]

Abstract

New biodegradable pH-responsive hydrogel beads based on chemically modified chitosan and sodium alginate were prepared and characterized for the controlled release study of protein drugs in the small intestine. The ionotropic gelation reaction was carried out under mild aqueous conditions, which should be appropriate for the retention of the biological activity of an uploaded protein drug. The equilibrium swelling studies were carried out for the hydrogel beads at 37 degrees C in simulated gastric (SGF) and simulated intestinal (SIF) fluids. Bovine serum albumin (BSA), a model for protein drugs was entrapped in the hydrogels and the in vitro drug release profiles were established at 37 degrees C in SGF and SIR The preliminary investigation of the hydrogel beads prepared in this study showed high entrapment efficiency (up to 97%) and promising release profiles of BSA. (C) 2009 Wiley Periodicals, Inc. J Appl Polym Sci 115: 2828-2837, 2010

Author Keywords: hydrogels; chitosan; grafting; alginate; protein drugs
KeyWords Plus: SOLUBLE CHITOSAN DERIVATIVES; GRAFT-COPOLYMERIZATION; CARBOXYMETHYL CHITOSAN; ANTIBACTERIAL ACTIVITY; AGGREGATION BEHAVIOR; INTESTINAL DELIVERY; METHYL ACRYLATE; ALGINATE; WATER; CALCIUM
Reprint Address: Harding, DRK (reprint author), Massey Univ, Inst Fundamental Sci, Dept Chem, Palmerston North, New Zealand.
Source: JOURNAL OF APPLIED POLYMER SCIENCE Volume: 115 Issue: 5 Pages: 2828-2837 DOI: 10.1002/app.30881 Published: MAR 5 2010

Addresses:
[1] Massey Univ, Inst Fundamental Sci, Dept Chem, Palmerston North, New Zealand
[2] Mansoura Univ, Polymer Lab, Dept Chem, Fac Sci, ET-35516 Mansoura, Egypt
E-mail Address: d.r.harding@massey.ac.nz
Publisher: JOHN WILEY & SONS INC, 111 RIVER ST, HOBOKEN, NJ 07030 USA
Web of Science Categories: Polymer Science
Research Areas: Polymer Science

References:

1-*Breimer, D. D. J Control Release 1999, **62**, 3.*

2 -*Ramadas, M.; Paul, W.; Dileep, K. J.; Anitha, Y.; Sharma, C. P. J Microencapsul 2000, **17**, 405.*

3 - *Liu, Z.; Jiao, Y.; Zhang, Z. J Appl Polym Sci 2007, **103**, 3164.*

*4-Mi, F. L.; Liang, H. F.; Wu, Y. C.; Lin, Y. S.; Yang, T. F.; Sung, H. W. J Biomater Sci Polym Ed 2005, **16**, 1333.*

5-*Kim, H. K.; Park, T. G. Biotechnol Bioeng 1999, **65**, 659.*

6-*Heller, J.; Barr, J.; Ng, S.; Shen, H.; Gurny, R.; Schwach-Abdelaoui, K.; Rothen-Weinhold, A.; Van de Weert, M. J Control Release 2002, **78**, 133.*

7 -*Bouillot, P.; Ubrich, N.; Sommer, F.; Duc, T. M.; Loeffler, J. P.; Dellacherie, E. Int J Pharm 1999, **181**, 159.*

8 -*Ju, H. K.; Kim, S. Y.; Kim, S. J.; Lee, Y. M. J Appl Polym Sci 2002, **83**, 1128.*

9 -*Qu, X.; Wirse'n, A.; Albertsson, A. C. Polymer 2000, **41**, 4589.*

10 -*Bronsted, H.; Kopecek, J. Biomaterials 1991, **12**, 584.*

11 - *Decho, A. W. Carbohydr Res 1999, **315**, 330.*

12 -*Vandenberg, G. W.; Drolet, C.; Scott, S. L.; de la Noue, J. J Control Release 2001, **77**, 297.*

13-*Hari, P. R.; Chandy, T.; Sharma, C. P. J Microencapsul 1996, **13**, 319.*

14 -*Lin, Y. H.; Liang, H. F.; Chung, C. K.; Chen, M. C.; Sung, H. W. Biomaterials 2005, **26**, 2105.*

15 -*Muzzarelli, R.; Baldassarre, V.; Conti, F.; Ferrara, P.; Biagini, G.; Gazzanelli, G.; Vasi, V. Biomaterials 1988, **9**, 247.*

16 -*Hirano, S.; Seino, H.; Akiyama, Y.; Nonaka, I. In Chitosan: A Biocompatable Material for Oral and Intravenous Administration; Gebelin, C. G., Dunn, R. L., Eds.; Progress in Biomedical Polymers: New York, 1990; p 283.*

17 -*Wang, P. F.; Wu, S. H. K.; Shi, X. Y.; Deng, B. M.; Sun, C. J Mater Sci 1998, **33**, 1753.*

18 -*Xie, W. M.; Xu, P. X.; Wang, W.; Liu, Q. Carbohydr Polym 2002, **50**, 35.*
19-*Muzzarelli, R. A. A. Carbohydr Polym 1988, **8**, 1.*

20 -*Janvikul, W.; Thavornyutikarn, B. J Appl Polym Sci 2003, **90**, 4016.*

21 -*Chen, L.; Du, Y.; Tian, Z.; Sun, L. J Polym Sci Polym Phys 2005, **43**, 296.*

Muzzarelli, R. A. A.; Ramos, V.; Stanic, V.; Dubini, B. Carbohydr Polym 1998, ***36****, 267.*

23 -*Liu, Y. H.; Liu, Z. H.; Zhang, Y. Z.; Deng, K. L. J Macromol Sci A 2002,* ***39****, 129.*

24 -*Ohya, Y.; Maruhashi, S.; Shizuno, K.; Mano, S.; Murata, J.; Ouchi, T. J Macromol Sci A 1999,* ***36****, 339.*

25 -*Hamit, C.; Hatice, H.; Osman, Y.; Elvan, Y. Eur Polym J 1998,* ***34****, 493.*

26 -*Radhakumary, C.; Divya, G.; Nair, P. D.; Mathew, S.; Nair, C. P. R. J Macromol Sci A 2003,* ***40****, 715.*

27-*Jenkins, D. W.; Hudson, S. M. Macromolecules 2002,* ***35****, 3413.*

28 -*Don, T. M.; King, C. F.; Chiu, W. Y. J Appl Polym Sci 2002,* ***86****, 3057.*

29-Li, Y. P.; Liu, L.; Fang, Y. E. Polym Int 2003, ***52****, 285.*

30-Sun, T.; Xu, P.; Liu, Q.; Xue, J.; Xie, W. Eur Polym J 2003, ***39****, 189.*

31-Zhu, A.; Zhang, M.; Zhang, Z. Polym Int 2004, ***53****, 15.*

32-Xie, W.; Xu, P.; Liu, Q. Bioorg Med Chem Lett 2001, ***11****, 1699.*

33 –*Sun, T.; Xie, W.; Xu, P. Carbohydr Polym 2004,* ***58****, 379.*

34-Xie, W.; Xu, P.; Wang, W.; Liu, Q. J Appl Polym Sci 2002, ***85****, 1357.*

35 -*Bradford, M. M. Anal Biochem 1976,* ***72****, 248.*

Novel cryomilled physically cross-linked biodegradable hydrogel microparticles as carriers for inhalation therapy

El-Sherbiny, IM (El-Sherbiny, I. M.)[1,2,3]; Smyth, HDC (Smyth, H. D. C.)[1,2,4]

Abstract

In this study, novel biodegradable physically cross-linked hydrogel microparticles were developed and evaluated in-vitro as potential carriers for inhalation therapy. These hydrogel microparticles were prepared to be respirable (desired aerodynamic size) when dry and also designed to avoid the macrophage uptake (attain large swollen size once deposited in lung). The swellable microparticles, prepared using cryomilling, were based on Pluronic (R) F-108 in combination with PEG grafted onto both chitosan (Cs) and its N-phthaloyl derivative (NPHCs). Polymers synthesized in the study were characterized using EA, FTIR, 2D-XRD and DSC. Morphology, particle size, density, biodegradation and moisture content of the microparticles were quantified. Swelling characteristics for both drug-free and drug-loaded microparticles showed excellent size increases (between 700-1300%) and the release profiles indicated sustained release could be achieved for up to 20 days. The respirable microparticles showed drug loading efficiency up to 92%. The enzymatic degradation of developed microparticles started within the first hour and only similar to 10% weights were remaining after 10 days. In conclusion, these respirable microparticles demonstrated promising in-vitro performance for potential sustained release vectors in pulmonary drug delivery.</.

Source: JOURNAL OF MICROENCAPSULATION **Volume:** 27 **Issue:** 8 **Pages:** 657-668 **DOI:** 10.3109/02652041003739840 **Published:** 2010

KeyWords Plus: GRAFTED CHITOSAN NANOPARTICLES; IN-VITRO; DELIVERY; MICROSPHERES; MACROPHAGES; NANOSPHERE; PACLITAXEL

Reprint Address: Smyth, HDC (reprint author), Univ Texas Austin, Coll Pharm, Austin, TX 78712 USA.

Addresses:
[1] Univ Texas Austin, Coll Pharm, Austin, TX 78712 USA
[2] Univ New Mexico, Coll Pharm, Div Pharmaceut Sci, Albuquerque, NM 87131 USA
[3] Mansoura Univ, Fac Sci, Dept Chem, Polymer Lab, Mansoura, Egypt
[4] Lovelace Resp Res Inst, Albuquerque, NM USA

E-mail Address: hsmyth@mail.utexas.edu

Publisher: INFORMA HEALTHCARE, TELEPHONE HOUSE, 69-77 PAUL STREET, LONDON EC2A 4LQ, ENGLAND

Web of Science Categories: Chemistry, Applied; Engineering, Chemical; Pharmacology & Pharmacy

Research Areas: Chemistry; Engineering; Pharmacology & Pharmacy

References:

1-Title: Targeting to macrophages: role of physicochemical properties of particulate carriers-liposomes and microspheres-on the phagocytosis by macrophages
Author(s): Ahsan, FL; Rivas, IP; Khan, MA; et al.
Source: JOURNAL OF CONTROLLED RELEASE Volume: 79 Issue: 1-3 Pages: 29-40 Article

2-Title: Pluronic block copolymers: Evolution of drug delivery concept from inert nanocarriers to biological response modifiers
Author(s): Batrakova, Elena V.; Kabanov, Alexander V.
Source: JOURNAL OF CONTROLLED RELEASE Volume: 130 Issue: 2 Pages: 98-106 DOI: 10.1016/j.jconrel.2008.04.013 Published: SEP 10 2008

3-Title: Swelling characteristics and in vitro drug release study with pH- and thermally sensitive hydrogels based on modified chitosan
Author(s): El-Sherbiny, I.M.; Abdel-Bary, E.M.; Harding, D.R.K.
Source: Journal of Applied Polymer Science Volume: 102 Issue: 2 Pages: 977-85 DOI: 10.1002/app.23989 Published: 15 Oct. 2006

4-Title: [not available]
Author(s): ELSHERBINY IM

Source: J PHARM SCI Volume: 9999 Pages: 1 Published: 2009
Times Cited: 2 (from All Databases)

5- Title: Temperature-sensitive hydrogels: Potential therapeutic applications. Technology tool
Author(s): Grassi, G; Farra, R; Caliceti, P; et al.
Source: Am J Drug Deliv Volume: 4 Pages: 239-251 DOI: 10.2165/00137696-200503040-00004 Published: 2005

6-Title: Chitosan nanoparticles are compatible with respiratory epithelial cells in vitro
Author(s): Grenha, Ana; Grainger, Christopher I.; Dailey, Lea Ann; et al.
Source: EUROPEAN JOURNAL OF PHARMACEUTICAL SCIENCES Volume: 31 Issue: 2 Pages: 73-84 DOI: 10.1016/j.ejps.2007.02.008 Published: JUN 2007

7- Title: N-ACETYLATION IN CHITOSAN AND THE RATE OF ITS ENZYMIC-HYDROLYSIS

Author(s): HIRANO, S; TSUCHIDA, H; NAGAO, N
Source: BIOMATERIALS Volume: 10 Issue: 8 Pages: 574-576 DOI: 10.1016/0142-9612(89)90066-5 Published: OCT 1989

8-Title: Synthesis and the micellar characteristics of poly(ethylene oxide)-deoxycholic acid conjugates

Author(s): Kim, C; Lee, SC; Kang, SW; et al.
Source: LANGMUIR Volume: 16 Issue: 11 Pages: 4792-4797 DOI: 10.1021/la9907634 Published: MAY 30 2000

9-Title: Phagocytic uptake of polystyrene microspheres by alveolar macrophages: effects of the size and surface properties of the microspheres
Author(s): Makino, K; Yamamoto, N; Higuchi, K; et al.
Source: COLLOIDS AND SURFACES B-BIOINTERFACES Volume: 27 Issue: 1 Pages: 33-39 Article Number: PII S0927-7765(02)00042-5 DOI: 10.1016/S0927-7765(02)00042-5 Published: JAN 2003

10-Title: [not available]
Author(s): MAOA S
Source: BIOMATERIALS Volume: 26 Pages: 6343 Published: 2005

11-Title: Issues in drug delivery: concepts and practice. (View record in MEDLINE)
Author(s): Martonen, Ted B; Smyth, Hugh D; Isaacs, Kristin K; et al.
Source: Respiratory care Volume: 50 Issue: 9 Pages: 1228-52 Published: 2005-Sep

12-Title: Localized delivery of paclitaxel in solid tumors from biodegradable chitin microparticle formulations

Author(s): Nsereko, S; Amiji, M
Source: BIOMATERIALS Volume: 23 Issue: 13 Pages: 2723-2731 Article Number: PII S0142-9612(02)00005-4 DOI: 10.1016/S0142-9612(02)00005-4 Published: JUL 2002
13-Title: Preparation of PEG-grafted chitosan nanoparticles as peptide drug carriers -Author(s): Ohya, Y; Cai, R; Nishizawa, H; et al.

14-SourcTitle: Incorporation of camptothecin into N-phthaloyl chitosan-g-mPEG self-assembly micellar system

Author(s): Opanasopit, Praneet; Ngawhirunpat, Tanasait; Chaidedgumjorn, Amornrut; et al.

Source: EUROPEAN JOURNAL OF PHARMACEUTICS AND BIOPHARMACEUTICS Volume: 64 Issue: 3 Pages: 269-276 DOI: 10.1016/j.ejpb.2006.06.001 Published: NOV 2006 e: S

15. Title: N-Phthaloylchitosan-g-mPEG design for all-trans retinoic acid-loaded polymeric micelles
Author(s): Opanasopit, Praneet; Ngawhirunpat, Tanasait; Rojanarata, Theerasak; et al.
Source: EUROPEAN JOURNAL OF PHARMACEUTICAL SCIENCES Volume: 30 Issue: 5 Pages: 424-431 DOI: 10.1016/j.ejps.2007.01.002 Published: APR 2007

TP PHARMA SCIENCES Volume: 10 Issue: 1 Pages: 77-82 Published: JAN-FEB 2000

16-Title: Self-assembled nanoparticles based on glycol chitosan bearing hydrophobic moieties as carriers for doxorubicin: In vivo biodistribution and anti-tumor activity

Author(s): Park, JH; Kwon, S; Lee, M; et al.
Source: BIOMATERIALS Volume: 27 Issue: 1 Pages: 119-126 DOI: 10.1016/j.biomaterials.2005.05.028 Published: JAN 2006

17-Title: Chitosan-PEG nanocapsules as new carriers for oral peptide delivery - Effect of chitosan pegylation degree
Author(s): Prego, C; Torres, D; Fernandez-Megia, E; et al.
Source: JOURNAL OF CONTROLLED RELEASE Volume: 111 Issue: 3 Pages: 299-308 DOI: 10.1016/j.jconrel.2005.12.015 Published: APR 10 2006
18-Title: Reghunadhan Nair CR Bio-polymer composite of chitosan and methyl methacrylate for medical applications

Author(s): Radhakumary, C; Nair, PD; Mathew, S.
Source: Trends Biomater Artif Organs Volume: 18 Pages: 117-24 Published: 2005
19-Title: [not available]

Author(s): SMYTH HDC
Source: AM J DRUG DELIV Volume: 3 Pages: 29 Published: 2005
Times Cited: 2 (from All Databases)

20-Title: [not available]

Author(s): SMYTH HDC
Source: AM J DRUG DELIV Volume: 3 Pages: 29 Published: 2005

21-Title: Hydrogel optimization for cultured elastic chondrocytes seeded onto a polyglycolic acid scaffold
Author(s): Terada, S; Yoshimoto, H; Fuchs, JR; et al.
Conference: 47th Annual Meeting of the Plastic-Surgery-Research-Council Location: BOSTON, MA Date: APR 17-20, 2002
Sponsor(s): Plast Surg Res Council
Source: JOURNAL OF BIOMEDICAL MATERIALS RESEARCH PART A Volume: 75A Issue: 4 Pages: 907-916 DOI: 10.1002/jbm.a.30505 Published: DEC 15 2005

22-Title: Preparation of poly(ethylene glycol)/chitosan membranes by a glucose-mediating process and in vitro drug release
Author(s): Wang, JW; Hon, MH
Source: JOURNAL OF APPLIED POLYMER SCIENCE Volume: 96 Issue: 4 Pages: 1083-1094 DOI: 10.1002/app.21506 Published: MAY 15 2005

23-Title: Adhesion and biofilm formation of *Candida albicans* on native and Pluronic-treated polystyrene.
Author(s): Wesenberg-Ward, K. E.; Tyler, B. J.; Sears, J. T.
Source: Biofilms Volume: 2 Issue: 1 Pages: 63-71 DOI: 10.1017/S1479050505001687 Published: 2005

Synthesis, characterization and metal uptake capacity of a new carboxymethyl chitosan derivative

El-Sherbiny, IM (El-Sherbiny, I. M.)

Abstract

Chemical modification of chitosan (Cs) and its derivatives via graft copolymerization can enhance their properties and consequently expands their potential applications. Carboxymethyl chitosan (CMCs) was prepared and characterized by FTIR spectroscopy, elemental analysis and X-ray diffraction. Graft copolymerization of N-acryloylglycine (NAGly) onto CMCs; using 2,2-dimethoxy-2-phenyl acetophenone (PI) as photoinitiator was carried out under nitrogen atmosphere in aqueous solution. Evidence of grafting was confirmed by comparison of FTIR spectra of CMCs and the graft copolymers as well as the 2D-X-ray diffraction patterns, elemental analysis and the difference in solubility profiles before and after grafting. The effects of concentration of NAGly, PI and reaction time on the extent of grafting were investigated by determining the grafting percentage and grafting efficiency. With other conditions kept constant, the obtained optimum grafting conditions were: CMCs = 0.1 g, NAGly = 0.4 g, PI = 0.02 g and reaction time = 1 h. A preliminary study was then carried out to evaluate the capacity of the prepared new graft copolymer to uptake copper ions from aqueous systems. This preliminary investigation of the prepared graft copolymers showed that they may be tailored and exploited to expand the utilization of these systems in metal ions uptake and treatment of wastewater. (C) 2008 Elsevier Ltd. All rights reserved.
Source: EUROPEAN POLYMER JOURNAL **Volume:** 45 **Issue:** 1 **Pages:** 199-210 **DOI:** 10.1016/j.eurpolymj.2008.10.042 **Published:** JAN 2009

Author Keywords: N-Acryloylglycine; Carboxymethyl chitosan; Swelling; Metal uptake

KeyWords Plus: GRAFT-COPOLYMERIZATION; BIOLOGICAL-ACTIVITY; ANTIBACTERIAL ACTIVITY; CHEMICAL-MODIFICATION; AGGREGATION BEHAVIOR; AQUEOUS-SOLUTION; METHYL ACRYLATE; METHACRYLATE; CHITINS

Reprint Address: El-Sherbiny, IM (reprint author), Mansoura Univ, Polymer Lab, Dept Chem, Fac Sci, ET-35516 Mansoura, Egypt.

Addresses:
[1] Mansoura Univ, Polymer Lab, Dept Chem, Fac Sci, ET-35516 Mansoura, Egypt

E-mail Address: i-elsherbiny@yahoo.com

Publisher: PERGAMON-ELSEVIER SCIENCE LTD, THE BOULEVARD, LANGFORD LANE, KIDLINGTON, OXFORD OX5 1GB, ENGLAND

Web of Science Categories: Polymer Science

Research Areas: Polymer Science

References

[1] -R. Muzzarelli, V. Baldassarre, F. Conti, P. Ferrara, G. Biagini, G. Gazzanelli *et al.*

Biological activity of chitosan: ultrastructural study

Biomaterials, 9 (1988), pp. 247–252

[2]-M.J. Jigar, V.K. Sinha

Ceric ammonium nitrate induced grafting of polyacrylamide onto carboxymethyl chitosan

Carbohyd Polym, 67 (2007), pp. 427–435

[3] S. Hirano, H. Seino, Y. Akiyama, I. Nonaka

Chitosan: a biocompatable material for oral and intravenous administration

C.G. Gebelin, R.L. Dunn (Eds.), Progress in biomedical polymers, Plenum Press, New York (1990), p. 283

[4]-.F. Wang, S.H.K. Wu, X.Y. Shi, B.M. Deng, C. Sun

The aggregation behavior of chitosan bioelectret in aqueous solution using a fluorescence probe

J Mater Sci, 33 (1998), pp. 1753–1757

[5] -W.M. Xie, P.X. Xu, W. Wang, Q. Liu

Preparation and antibacterial activity of a water-soluble chitosan derivative

Carbohyd Polym, 50 (2002), pp. 35–40

[6]-R.A.A. Muzzarelli

Carboxymethylated chitins and chitosans

Carbohyd Polym, 8 (1988), pp. 1–21

[7]-L. Chen, Y. Du, Z. Tian, L. Sun

Effect of the degree of deacetylation and the substitution of carboxymethyl chitosan on its aggregation behavior

J Polym Sci Polym Phys, 43 (2005), pp. 296–305

[8] -Z. Liu, Y. Jiao, Z. Zhang

Calcium-carboxymethyl chitosan hydrogel beads for protein drug delivery system

J Appl Polym Sci, 103 (5) (2007), pp. 3164–3168

[9]W. Janvikul, B. Thavornyutikarn

New route to the preparation of carboxymethylchitosan hydrogels

J Appl Polym Sci, 90 (2003), pp. 4016–4020

[10]-R.A.A. Muzzarelli, V. Ramos, V. Stanic, B. Dubini

Osteogenesis promoted by calcium phosphate *N,N*-dicarboxymethyl chitosan

Carbohyd Polym, 36 (1998), pp. 267–276

[11]-M. Sugimoto, M. Morimoto, H. Sashiwa, H. Saimoto, Y. Shigemasa

Preparation and characterization of water-soluble chitin and chitosan derivatives

Carbohyd Polym, 36 (1) (1998), pp. 49–59

[12]-H. Sashiwa, Y. Shigemasa

Chemical modification of chitin and chitosan 2: Preparation and water soluble property of *N*-acetylated partially deacetylated chitins

Carbohyd Polym, 39 (2) (1999), pp. 127–138

[13]-N. Terada, M. Morimoto, H. Saimoto, Y. Okamoto, S. Minami, Y. Shigemasa

Synthesis of water-soluble oxidized chitosan derivatives and their biological activity

Chem Lett, 28 (12) (1999), pp. 1285–1292

[14]- T.R. Sridhari, P.K. Dutta

Synthesis and characterization of maleilated chitosan for dye house effluent

Indian J Chem Technol, 7 (4) (2000), pp. 198–201

[15]-A. Heras, N.M. Rodriguez, V.M. Ramos, E. Agullo

N-Methylene phosphonic chitosan: a novel soluble derivative

Carbohyd Polym, 44 (1) (2001), pp. 1–8

[16]-Y.H. Liu, Z.H. Liu, Y.Z. Zhang, K.L. Deng

Graft copolymerization of methyl acrylate onto chitosan initiated by potassium diperiodatonickelate (IV

J Macromol Sci A, 39 (2002), pp. 129–143

[17]-Y. Ohya, S. Maruhashi, K. Shizuno, S. Mano, J. Murata, T. Ouchi

Graft polymerization of styrene on chitosan and the characteristics of the copolymers

J Macromol Sci A, 36 (1999), pp. 339–353

[18]-C. Hamit, H. Hatice, Y. Osman, Y. Elvan

Graft copolymerization of 4-vinylpyridine onto chitosan. 1. By ceric ion initiation

Eur Polym J, 34 (1998), pp. 493–497

[19]-C. Radhakumary, G. Divya, P.D. Nair, S. Mathew, C.P.R. Nair

Graft copolymerization of 2-hydroxyethyl methacrylate onto chitosan with cerium (IV) ion. I. Synthesis and characterization

J Macromol Sci A, 40 (2003), pp. 715–730

[20] D.W. Jenkins, S.M. Hudson

Heterogeneous graft copolymerization of chitosan powder with methyl acrylate using trichloroacetyl-manganese carbonyl co-initiation

Macromolecules, 35 (2002), pp. 3413–3419

[21]-T.M. Don, C.F. King, W.Y. Chiu

Synthesis and properties of chitosan-modified poly(vinyl acetate)

J Appl Polym Sci, 86 (2002), pp. 3057–3063

[22]-Y.P. Li, L. Liu, Y.E. Fang

Plasma-induced grafting of hydroxyethyl methacrylate (HEMA) onto chitosan membranes by a swelling method

Polym Int, 52 (2003), pp. 285–290

[23]-J.M. Joshi, V.K. Sinha

Synthesis and characterization of carboxymethyl chitosan grafted methacrylic acid initiated by Ceric ammonium nitrate

J Polym Res, 13 (2006), pp. 387–395

[24]-J.M. Joshi, V.K. Sinha

Graft copolymerization of 2-hydroxyethylmethacrylate onto carboxymethyl chitosan using CAN as an initiator

Polymer, 47 (2006), pp. 2198–2204

[25]-T. Sun, P. Xu, Q. Liu, J. Xue, W. Xie

Graft copolymerization of methacrylic acid onto carboxymethyl chitosan

Eur Polym J, 39 (2003), pp. 189–192

[26]-A. Zhu, M. Zhang, Z. Zhang

Surface modification of ePTFE vascular grafts with *O*-carboxymethylchitosan

Polym Int, 53 (2004), pp. 15–19

[27]-W. Xie, P. Xu, Q. Liu

Antioxidant activity of water-soluble chitosan derivatives

Bioorg Med Chem Lett, 11 (2001), pp. 1699–1701

[28] T. Sun, W. Xie, P. Xu

Superoxide anion scavenging activity of graft chitosan derivatives

Carbohyd Polym, 58 (2004), pp. 379–382

[28] W. Xie, P. Xu, W. Wang, Q. Liu

Preparation of water-soluble chitosan derivatives and their antibacterial activity

J Appl Polym Sci, 85 (2002), pp. 1357–1361

[30] J.C.Y. Ng, W.H. Cheung, G. McKay

Equilibrium studies of the sorption of Cu(II) ions onto chitosan

J Colloid Interface Sci, 255 (2002), pp. 64–74

[31] G. McKay, Y.S. Ho, J.C.Y. Ng

Biosorption of copper from waste water: a review

Sep Purif Methods, 28 (1999), pp. 87–125

[32] G.A.F. Roberts

Solubility and solution behaviour of chitin and chitosan

,in: G.A.F. Roberts (Ed.), Chitin chemistryMacMillan, Houndmills (1992), p. 274

[33] G.A.F. Roberts, J.G. Domszy

Determination of the viscometric constants for chitosan

Int J Biol Macromol, 4 (1982), pp. 374–377

[34] A. Bentolila, I. Vlodavsky, C. Haloum, A.J. Domb

Synthesis and heparin-like biological activity of amino acid-based polymers

Polym Advan Technol, 11 (2000), pp. 377–387

[35] M. Camail, A. Margaillan, J.C. Maesano, S. Thuret, J.L. Vernet

Synthesis and structural study of new copolymers, based on acrylamide and N-acryloyl acids, with persistent drug reduction activity

[36] H.C. Ge, D.K. Luo

Preparation of carboxymethyl chitosan in aqueous solution under microwave irradiation

Carbohyd Res, 340 (2005), pp. 1351–1356

[37] K.L. Shantha, U. Bala, R.K. Panduranga

Tailor- made chitosans for drug delivery

Euro Polym J, 31 (4) (1995), pp. 317–382

[38] W. Li, Z.Y. Li, W.S. Liao, X.D. Feng

Chemical modification of biopolymers mechanism of model graft copolymerization of chitosan

J Biomat Sci Polym Ed, 4 (5) (1993), pp. 557–566

Grafting Study and Antifungal Activity of a Carboxymethyl Cellulose Derivative

El-Sherbiny, IM (El-Sherbiny, I. M.)[1,2]; Salama, A (Salama, A.)[3]; Sarhan, AA (Sarhan, A. A.)[1]

Abstract

Graft copolymerization of appropriate monomers onto cellulose and its derivatives can enhance their characteristics and consequently expand their potential applications. Carboxymethyl cellulose (CMC) was prepared and characterized by FTIR spectroscopy and XRD. Graft copolymerization of acrylic acid sodium salt (AAs) onto CMC using ammonium persulfate (APS) as a free radical initiator was carried out under nitrogen atmosphere in aqueous solution. Occurrence of grafting was confirmed by comparison of FTIR spectra of CMC and the graft copolymers as well as the XRD patterns and thermal analysis. The effects of concentration of AA, temperature, concentration of APS and reaction time on the grafting yield were investigated by determining the grafting percentage and grafting efficiency. With other conditions kept constant, the obtained optimum grafting conditions were: CMC = 0.2 g, [AAs] = 2 mM, [APS] = 7.5 mM, temperature 70 degrees C and reaction time = 2 h. A preliminary study was then carried out to evaluate the antifungal activity of the prepared graft copolymer. This preliminary investigation of the prepared graft copolymers showed that they may be tailored and exploited to expand the utilization of these systems in medical applications.

Source: INTERNATIONAL JOURNAL OF POLYMERIC MATERIALS **Volume:** 58 **Issue:** 9 **Pages:** 453-467 **DOI:** 10.1080/00914030902936519 **Published:** 2009

Author Keywords: antifungal; carboxymethyl cellulose; grafting

KeyWords Plus: ELECTRON-BEAM IRRADIATION; ACRYLIC-ACID; POLYMERIZATION; POLYACRYLAMIDE; METHACRYLATE; POLYMERS

Reprint Address: El-Sherbiny, IM (reprint author), Mansoura Univ, Fac Sci, Dept Chem, Polymer Lab, ET-35516 Mansoura, Egypt.

Addresses:
[1] Mansoura Univ, Fac Sci, Dept Chem, Polymer Lab, ET-35516 Mansoura, Egypt
[2] Univ New Mexico, Coll Pharm, Div Pharmaceut Sci, Albuquerque, NM 87131 USA
[3] Natl Res Ctr, Cellulose & Paper Dept, Cairo, Egypt

E-mail Address: i_elsherbiny@yahoo.com

Publisher: TAYLOR & FRANCIS AS, KARL JOHANS GATE 5, NO-0154 OSLO, NORWAY

Web of Science Categories: Polymer Science

Research Areas: Polymer Science

IDS Number: 458SX

ISSN: 0091-4037

References:

1. Title: Graft polymerization: Starch as a model substrate

Author(s): Athawale, VD; Rathi, SC

Source: JOURNAL OF MACROMOLECULAR SCIENCE-REVIEWS IN MACROMOLECULAR CHEMISTRY AND PHYSICS Volume: C39 Issue: 3

2. Title: [not available]

Author(s): BECK RHF

Source: HDB POLYM SYNTHESI B Published: 1992

3. Title: Characterisation of carboxymethyl cellulose and polyacrylamide graft copolymer

Author(s): Biswal, DR; Singh, RP

Source: CARBOHYDRATE POLYMERS Volume: 57 Issue: 4 Pages: 379-387 DOI: 10.1016/j.carbpol.2004.04.020 Published: SEP 22 2004

4. Title: Flocculation studies based on water-soluble polymers of grafted carboxymethyl cellulose and polyacrylamide

Author(s): Biswal, D. R.; Singh, R. P.

Source: JOURNAL OF APPLIED POLYMER SCIENCE Volume: 102 Issue: 2 Pages: 1000-1007 DOI: 10.1002/app.24016 Published: OCT 15 2006

5. Title: Medicinal microbiology

Author(s): Cruickshank, R; Duguid, JP; Marion, BP; et al; Swain, RHA.

Source: MED MICROBIOLOGY Published: 1975

Publisher: Churchill Livingstone, London

6. Title: Temperature and pH responsive behaviours of CMC/AAc hydrogels prepared by electron beam irradiation

Author(s): El-Naggar, AWM; Alla, SGA; Said, HM

Source: MATERIALS CHEMISTRY AND PHYSICS Volume: 95 Issue: 1 Pages: 158-163 DOI: 10.1016/j.matchemphys.2005.05.037 Published: JAN 10 2006

7. Title: [not available]

Author(s): KOBATA A

Source: GLYCOBIOLOGY Volume: 11 Pages: 99 Published: 2001

8. Title: Controlled functionalization of the polysaccharide chitin

Author(s): Kurita, K

Source: PROGRESS IN POLYMER SCIENCE Volume: 26 Issue: 9 Pages: 1921-1971 DOI: 10.1016/S0079-6700(01)00007-7 Published: NOV 2001

9. Title: Water-absorbing characteristics of acrylic acid-grafted carboxymethyl cellulose synthesized by photografting

Author(s): Kuwabara, S; Kubota, H

Source: JOURNAL OF APPLIED POLYMER SCIENCE Volume: 60 Issue: 11 Pages: 1965-1970 DOI: 10.1002/(SICI)1097-4628(19960613)60:11<1965::AID-APP20>3.0.CO;2-Z Published: JUN 13 1996

10. Title: Grafting of sodium carboxymethylcellulose (CMC) with glycidyl methacrylate and development of UV curable coatings from CMC-g-GMA induced by cationic photoinitiators

Author(s): Lin, OH; Kumar, RN; Rozman, HD; et al.

Source: CARBOHYDRATE POLYMERS Volume: 59 Issue: 1 Pages: 57-69 DOI: 10.1016/j.carbpol.2004.08.027 Published: JAN 3 2005

11. Title: [not available]

Author(s): Majewicz, TG; Podlas, TJ.

Source: Encyclopedia of chemical technology Published: 1966

Publisher: Wiley, New York

12. Title: Physical-chemical characterisation of acrylic polymers grafted on cellulose

Author(s): Margutti, S; Vicini, S; Proietti, N; et al.

Source: POLYMER Volume: 43 Issue: 23 Pages: 6183-6194 Article Number: PII S0032-3861(02)00533-5 DOI: 10.1016/S0032-3861(02)00533-5 Published: NOV 2002

13. Title: Radiation grafting studies of acrylic acid onto cellulose triacetate membranes

Author(s): Mazzei, RO; Smolko, E; Torres, A; et al.

Source: RADIATION PHYSICS AND CHEMISTRY Volume: 64 Issue: 2 Pages: 149-160 Article Number: PII S0969-806X(01)00457-1 DOI: 10.1016/S0969-806X(01)00457-1 Published: MAY 2002

14. Title: Efficiency of ceric lone for oxidation and polymerization - A review

Author(s): Nagarajan, S; Srinivasan, KSV

Source: JOURNAL OF MACROMOLECULAR SCIENCE-REVIEWS IN MACROMOLECULAR CHEMISTRY AND PHYSICS Volume: C38 Issue: 1 Pages: 53-76 DOI: 10.1080/10601329808006894 Published: 1998

15. Title: Graft copolymerizations of modified cellulose: Grafting of methyl acrylate, ethyl acrylate and ethyl methacrylate on carboxy methyl cellulose

Author(s): Okieimen, FE; Ogbeifun, DE

Source: EUROPEAN POLYMER JOURNAL Volume: 32 Issue: 3 Pages: 311-315 DOI: 10.1016/0014-3057(95)00152-2 Published: MAR 1996

16. Title: Grafting polymerization on cellulose based textiles: A C-13 solid state NMR characterization

Author(s): Princi, E; Vicini, S; Proietti, N; et al.

Source: EUROPEAN POLYMER JOURNAL Volume: 41 Issue: 6 Pages: 1196-1203 DOI: 10.1016/j.europolymj.2005.01.009 Published: JUN 2005

17. Title: Optimization of reaction conditions for preparing carboxymethyl cellulose from sago waste

Author(s): Pushpamalar, V; Langford, SJ; Ahmad, M; et al.

Source: CARBOHYDRATE POLYMERS Volume: 64 Issue: 2 Pages: 312-318 DOI: 10.1016/j.carbpol.2005.12.003 Published: MAY 11 2006

18. Title: [not available]

Author(s): RADEMACHER TN

Source: ANNU REV BIOCHEM Volume: 57 Pages: 785 Published: 1998

19. Title: Synthesis and characterization of novel gels based on carboxymethyl cellulose/acrylic acid prepared by electron beam irradiation

Author(s): Said, HM; Abd Alla, SGA; El-Naggar, AWM

Source: REACTIVE & FUNCTIONAL POLYMERS Volume: 61 Issue: 3 Pages: 397-404 DOI: 10.1016/j.reactfunctpolym.2004.07.002 Published: 2004

20. Title: Tailor-made chitosans for drug delivery

Author(s): Shantha, K.L.; Panduranga Rao, K.; Udaya, Bala.

Source: Eur. Polym. J. Volume: 31 Pages: 317-382 Published: 1995

21. Title: Synthesis and properties of carboxymethyl cellulose-graft-poly(acrylic acid-co-acrylamide) as a novel cellulose-based superabsorbent

Author(s): Suo, Aili; Qian, Junmin; Yao, Yu; et al.

Source: JOURNAL OF APPLIED POLYMER SCIENCE Volume: 103 Issue: 3 Pages: 1382-1388
DOI: 10.1002/app.23948 Published: FEB 5 2007

22. Title: [not available]

Author(s): TAM KC

Source: POLYM MAT ENCY Published: 1996

Chitosan-based interpolymeric pH-responsive hydrogels for in vitro drug release

Abdelaal, MY (Abdelaal, M. Y.); Abdel-Razik, EA (Abdel-Razik, E. A.);

Abdel-Bary, EM (Abdel-Bary, E. M.); El-Sherbiny, IM (El-Sherbiny, I. M.)

Abstract

Two series of pH-responsive biodegradable interpolymeric (IPN) hydrogels based on chitosan (Ch) and poly(vinyl alcohol) (PVA) were prepared for controlled drug release investigations. The first series was chemically crosslinked with different concentrations of glutaraldehyde and the second was crosslinked upon gamma-irradiation by different doses. The equilibrium swelling characteristics were investigated for the gels at 37 degrees C in buffer solutions of pH 2.1 and 7.4 as simulated gastric and intestinal fluids, respectively. 5-Fluorouracil (FU) was entrapped in the hydrogels, as a model therapeutic agent, and the in vitro release profiles of the drug were established at 37 degrees C in pH 2.1 and 7.4. FTIR, SEM, and X-ray diffraction analyses were used to characterize and investigate the structural changes of the gels with the variation of the blend composition and crosslinker content before and after the drug loading. (c) 2006 Wiley Periodicals, Inc.

Source: JOURNAL OF APPLIED POLYMER SCIENCE Volume: 103 Issue: 5 Pages: 2864-2874 DOI: 10.1002/app.25154 Published: MAR 5 2007

Author Keywords: hydrogel; drug delivery systems; gelation; interpenetrating network; irradiation

KeyWords Plus: GAMMA-RAY IRRADIATION; AQUEOUS-SOLUTION; CROSS-LINKING; SWELLING BEHAVIOR; POLYMERS; ALCOHOL); RADIATION

Reprint Address: Abdelaal, MY (reprint author), Mansoura Univ, Fac Sci, Dept Chem, Mansoura 35516, Egypt.

Addresses:
[1] Mansoura Univ, Fac Sci, Dept Chem, Mansoura 35516, Egypt

E-mail Address: magdyabdelaal@yahoo.com

Publisher: JOHN WILEY & SONS INC, 111 RIVER ST, HOBOKEN, NJ 07030 USA

Web of Science Categories: Polymer Science

Research Areas: Polymer Science

References:

1. Title: Synthesis and characterization of polydi(3,4-dihydro-2H-pyran-2-methyl) adipate hydrogel

Author(s): Abbas, YA; Abdelaal, MY

Source: POLYMER BULLETIN Volume: 36 Issue: 3 Pages: 273-278 DOI: 10.1007/BF00319225 Published: MAR 1996

2. Title: Structural properties of gamma-irradiated poly(vinyl alcohol)/poly(ethylene glycol) polymer blends

Author(s): Abd Alla, SG; Said, HM; El-Naggar, AWM

Source: JOURNAL OF APPLIED POLYMER SCIENCE Volume: 94 Issue: 1 Pages: 167-176 DOI: 10.1002/app.20842 Published: OCT 5 2004

3. Title: THE ROLE AND UTILIZATION OF TETRACHLOROSILANE ETHANOL REAGENT IN THE CROSS-LINKING OF POLY(P-VINYLACETOPHENONE)

Author(s): ABDELAAL, MY; ELMORSY, SS

Source: ANGEWANDTE MAKROMOLEKULARE CHEMIE Volume: 233 Pages: 15-21 DOI: 10.1002/apmc.1995.052330102 Published: NOV 1995

4. Title: Synthesis of novel ladder polymers of poly(3,4-dihydro-2H-pyran-2-methanol)

Author(s): Abdelaal, MY

Source: JOURNAL OF POLYMER SCIENCE PART A-POLYMER CHEMISTRY Volume: 40 Issue: 22 Pages: 3909-3915 DOI: 10.1002/pola.10469 Published: NOV 15 2002

5. Title: Synthesis and characterization of polyesters based on 3,4-dihydro-2H-pyran-2-yl-methanol

Author(s): Abdelaal, MY; Abbas, YA

Source: MONATSHEFTE FUR CHEMIE Volume: 127 Issue: 11 Pages: 1131-1136 DOI: 10.1007/BF00844687 Published: NOV 1996

6. Title: Radiation and industrial polymers

Author(s): Bhattacharya, A

Source: PROGRESS IN POLYMER SCIENCE Volume: 25 Issue: 3 Pages: 371-401 DOI: 10.1016/S0079-6700(00)00009-5 Published: APR 2000

7. Title: Preparation, characterization, swelling and in vitro drug release behaviour of poly [N-acryloylglycine-chitosan interpolymeric pH and thermally-responsive hydrogels

Author(s): El-Sherbiny, IM; Lins, RJ; Abdel-Bary, EM; et al.

Source: EUROPEAN POLYMER JOURNAL Volume: 41 Issue: 11 Pages: 2584-2591 DOI: 10.1016/j.eurpolymj.2005.05.035 Published: NOV 2005

8. Title: Selected properties of pH-sensitive, biodegradable chitosan-poly(vinyl alcohol) hydrogel

Author(s): Wang, T; Turhan, M; Gunasekaran, S

Source: POLYMER INTERNATIONAL Volume: 53 Issue: 7 Pages: 911-918 DOI: 10.1002/pi.1461 Published: JUL 2004

9. Title: Semi-interpenetrating polymer network beads of crosslinked chitosan-glycine for controlled release of chlorphenramine maleate

Author(s): Gupta, KC; Kumar, MNVR

Source: JOURNAL OF APPLIED POLYMER SCIENCE Volume: 76 Issue: 5 Pages: 672-683 DOI: 10.1002/(SICI)1097-4628(20000502)76:5<672::AID-APP9>3.3.CO;2-6 Published: MAY 2 2000

10. Title: CHITOSAN - A BIOCOMPATIBLE MATERIAL FOR ORAL AND INTRAVENOUS ADMINISTRATIONS

Author(s): HIRANO, S; SEINO, H; AKIYAMA, Y; et al.

Book Editor(s): GEBELEIN, CG; DUNN, RL

Conference: SYMP AT THE 196TH NATIONAL MEETING OF THE AMERICAN CHEMICAL SOC Location: LOS ANGELES, CA Date: SEP 25-30, 1988

Sponsor(s): AMER CHEM SOC, DIV POLYM MAT SCI & ENGN

11. Title: SWELLING PROPERTIES OF COPOLYMERIC HYDROGELS PREPARED BY GAMMA-IRRADIATION

Author(s): HUGLIN, MB; ZAKARIA, MB

Source: JOURNAL OF APPLIED POLYMER SCIENCE Volume: 31 Issue: 2 Pages: 457-475 DOI: 10.1002/app.1986.070310213 Published: FEB 5 1986

Times Cited: 50 (from All Databases)

12. Title: Swelling behavior of acrylic acid hydrogels prepared by gamma-radiation crosslinking of polyacrylic acid in aqueous solution

Author(s): Jabbari, E; Nozari, S

Source: EUROPEAN POLYMER JOURNAL Volume: 36 Issue: 12 Pages: 2685-2692 DOI: 10.1016/S0014-3057(00)00044-6 Published: DEC 2000

Times Cited: 101 (from All Databases)

13. Title: Intrinsic viscosity-molecular weight relationship for chitosan

Author(s): Kasaai, MR; Arul, J; Charlet, C

Source: JOURNAL OF POLYMER SCIENCE PART B-POLYMER PHYSICS Volume: 38 Issue: 19 Pages: 2591-2598 DOI: 10.1002/1099-0488(20001001)38:19<2591::AID-POLB110>3.0.CO;2-6 Abstract Number: A2000-22-6620-005 Published: OCT 1 2000

Times Cited: 74 (from All Databases)

14. Title: Swelling behavior of interpenetrating polymer network hydrogels composed of poly(vinyl alcohol) and chitosan

Author(s): Kim, SJ; Park, SJ; Kim, SI

Source: REACTIVE & FUNCTIONAL POLYMERS Volume: 55 Issue: 1 Pages: 53-59 Article Number: PII S1381-5148(02)00214-6 DOI: 10.1016/S1381-5148(02)00214-6 Published: 2003

Times Cited: 79 (from All Databases)

15. Title: EFFECT OF THE CHEMICAL-STRUCTURE OF SOME HYDROGELS ON THEIR CHARACTERISTIC PROPERTIES .1. EFFECT OF COMONOMER COMPOSITION

Author(s): KOSSMEHL, GA; ABDELBARY, EM; SARHAN, AA; et al.

Source: ANGEWANDTE MAKROMOLEKULARE CHEMIE Volume: 215 Pages: 59-77 DOI: 10.1002/apmc.1994.052150106 Published: FEB 1994

Times Cited: 11 (from All Databases)

16. Title: Chemical modification of chitin and Chitosan

Author(s): Kurita, K.

Editor(s): Muzzarelli, RA; Jeuniaux, C; Gooday, GW.

Source: Chitin in Nature and Technology Pages: 287-93 Published: 1986

Publisher: Plenum, New York

17. Title: [not available]

Author(s): Lapasin, R.; Pricl, S.

Source: Rheology of industrial polysaccharides. Theory and applications Published: 1995

Publisher: Blackie Academic and Professional, Chapman and Hall, London

18. Title: [not available]

Author(s): Martien, F.L.

Source: Encyclopedia of Polymer Science and Engineer Volume: 17 Pages: 167 Published: 1986

Publisher: Wiley, New York, NY, USA

19. Title: BIOLOGICAL-ACTIVITY OF CHITOSAN - ULTRASTRUCTURAL-STUDY

Author(s): MUZZARELLI, R; BALDASSARRE, V; CONTI, F; et al.

Source: BIOMATERIALS Volume: 9 Issue: 3 Pages: 247-252 DOI: 10.1016/0142-9612(88)90092-0 Published: MAY 1988

20. Title: Preparation of pH-sensitive poly(vinyl alcohol-g-methacrylic acid) and poly(vinyl alcohol-g-acrylic acid) hydrogels by gamma ray irradiation and their insulin release behavior

Author(s): Park, SE; Nho, YC; Lim, YM; et al.

Source: JOURNAL OF APPLIED POLYMER SCIENCE Volume: 91 Issue: 1 Pages: 636-643 DOI: 10.1002/app.13211 Published: JAN 5 2004

Times Cited: 41 (from All Databases)

21. Title: Solubility and solution behaviour of chitin and chitosan

Author(s): Roberts, GAF.

Editor(s): Roberts, GAF.

Source: Chitin Chemistry Volume: 274-329 Published: 1992

Publisher: MacMillan, Houndmills

22. Title: DETERMINATION OF THE VISCOMETRIC CONSTANTS FOR CHITOSAN

Author(s): ROBERTS, GAF; DOMSZY, JG

Source: INTERNATIONAL JOURNAL OF BIOLOGICAL MACROMOLECULES Volume: 4 Issue: 6 Pages: 374-377 DOI: 10.1016/0141-8130(82)90074-5 Published: 1982

23. Title: [not available]

Author(s): ROBERTS GAF

Source: MAKROMOL CHEM Volume: 1989 Pages: 951 Published: 2005

24. Title: Synthesis of hydrogels by irradiation of polymers in aqueous solution

Author(s): Rosiak, JM; Ulanski, P

Source: RADIATION PHYSICS AND CHEMISTRY Volume: 55 Issue: 2 Pages: 139-151 DOI: 10.1016/S0969-806X(98)00319-3 Published: JUN 1999

Times Cited: 143 (from All Databases)

25. Title: STUDIES ON CHITIN .2. EFFECT OF DEACETYLATION ON SOLUBILITY

Author(s): SANNAN, T; KURITA, K; IWAKURA, Y

Source: MAKROMOLEKULARE CHEMIE-MACROMOLECULAR CHEMISTRY AND PHYSICS Volume: 177 Issue: 12 Pages: 3589-3600 Published: 1976

26. Title: On the intermolecular crosslinking of PVA chains in an aqueous solution by gamma-ray irradiation

Author(s): Wang, BL; Kodama, M; Mukataka, S; et al.

Source: POLYMER GELS AND NETWORKS Volume: 6 Issue: 1 Pages: 71-81 DOI: 10.1016/S0966-7822(98)00003-3 Published: 1998

Times Cited: 24 (from All Databases)

27. Title: The aggregation behaviour of chitosan bioelectret in aqueous solution using a fluorescence probe

Author(s): Wang, PF; Wu, SK; Shi, XY; et al.

Source: JOURNAL OF MATERIALS SCIENCE Volume: 33 Issue: 7 Pages: 1753-1757 DOI: 10.1023/A:1004324531314 Abstract Number: A1998-11-8715-018 Published: APR 1 1998

Times Cited: 16 (from All Databases)

28. Title: Properties of chitosan/poly(vinyl alcohol) films for drug-controlled release

Author(s): Wang, Q; Du, YM; Fan, LH

Source: JOURNAL OF APPLIED POLYMER SCIENCE Volume: 96 Issue: 3 Pages: 808-813 DOI: 10.1002/app.21518 Published: MAY 5 2005

Times Cited: 29 (from All Databases)

29. Title: Preparation and antibacterial activity of a water-soluble chitosan derivative

Author(s): Xie, WM; Xu, PX; Wang, W; et al.

Source: CARBOHYDRATE POLYMERS Volume: 50 Issue: 1 Pages: 35-40 Article Number: PII S0144-8617(01)00370-8 DOI: 10.1016/S0144-8617(01)00370-8 Published: OCT 1 2002

Times Cited: 114 (from All Databases)

30. Title: An ESR study on gamma-irradiated poly (vinyl alcohol)

Author(s): Zainuddin, Z.; Hill, D. J. T.; Le, T. T.

Source: Radiat. Phys. Chem Volume: 62 Pages: 283-291 Published: 2001

Times Cited: 3 (from All Databases