CYCLODEXTRIN NEWS
VOLUME 27. No. 4. APRIL 2013 ISSN 0951-256X

Cyclodextrins in the Photodynamic Therapy

The photodynamic therapy was introduced to the cyclodextrin researchers at the Sixth International Cyclodextrin Symposium (Chicago, 1992) by Prof. Morgan who studied synthetic chlorophyll-type sensitizer, tin etiopurpurin dissolved in γCD and HPγCD to replace the synthetic surfactant, Chremophore [1]. Both CDs gave efficient concentration of this photosensitizer in the tumor in *in vivo* experiments. Since that, about 100 papers and conference publications have been published on CD application in photodynamic therapy, 20 of them in 2012, according to the *Cyclodextrin News Database*. The dynamics of the publications are shown in *Fig. 1.*

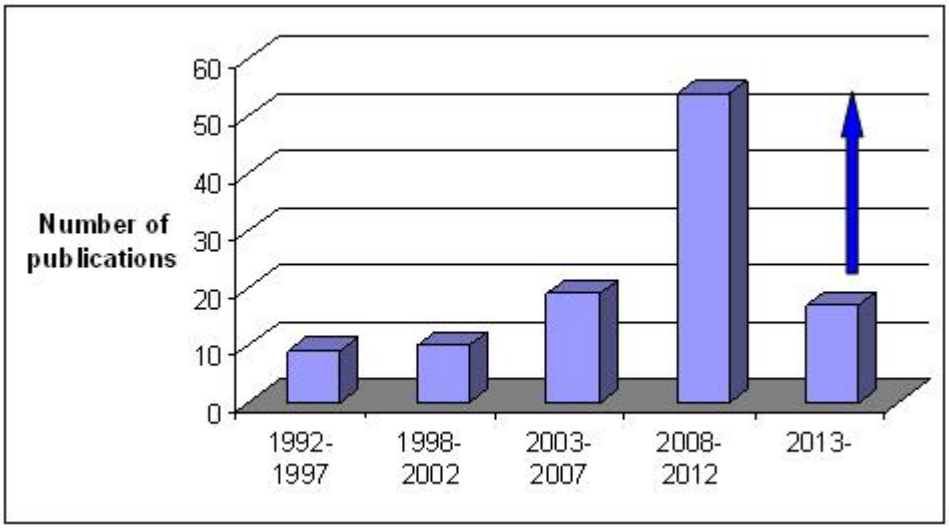

Fig. 1 Number of publications on CDs in photodynamic therapy in 5 year periods

Photodynamic therapy (PDT) is a new anticancer, antimicrobial therapy using light-sensitive compounds, which have anticancer/antibiotic effect only when irradiated by low power laser light. The photosensitizers produce reactive oxygen species (singlet oxygen or other oxygen radical species) which destroy the tissues/pathogens exposed to light. The therapy can be selectively targeted by applying either the photosensitizer or the light onto the target area. PDT is used for the skin disorders, such as acne, psoriasis and skin tumor applying both the photosensitizer and the light locally to the injured skin surface. When internal tumors are treated, either the PDT is used during surgery or the

photosensitizer is administered intravenously and the light is delivered through endoscopes or optical fibers. Nowadays when antibiotic resistance makes the conventional antibiotic therapies useless, PDT is one of the novel antimicrobial strategies because resistance will not readily develope against antibiotic PDT.

Photochemical internalization (PCI) is the novel technology for light-induced release of endocytosed macromolecules (proteins, plasmids, adenovira, nanoparticles) into the cytosol.

Cyclodextrins as carriers of various drug molecules can be vehicles of photosensitizers via complexation (*Fig. 2*). The complexes usually show improved solubility, stability, and changed aggregation behavior. In addition to complexation, there is another possibility: using photosensitizers conjugated to CDs (*Fig. 3*). In this case, the CD cavity can accommodate another anticancer or antibiotic compound making possible a two-way attack against cancer or pathogens.

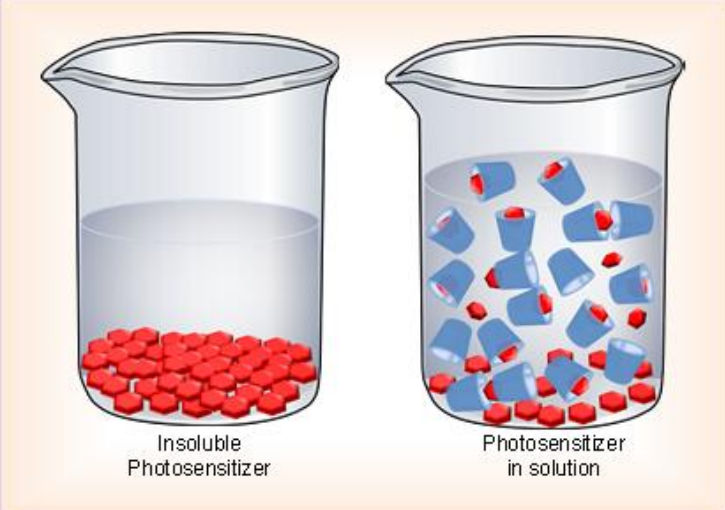

Fig.2 CD for enhancing the solubility of the poorly soluble photosensitizer

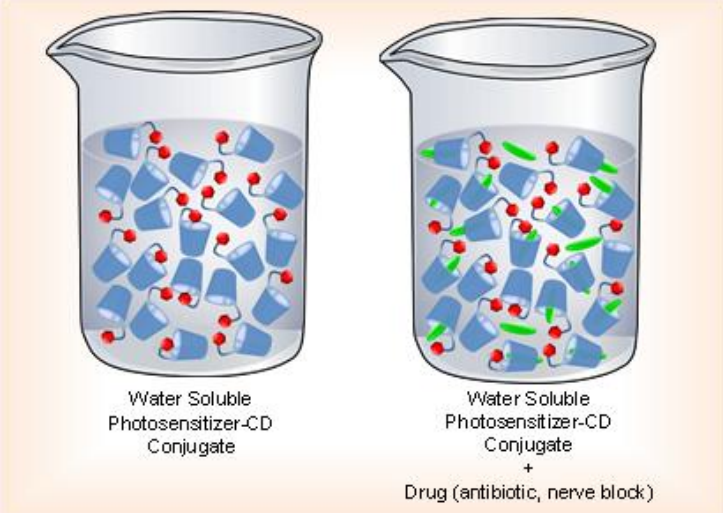

Fig. 3 Photosensitizer conjugated to CD can accommodate another anticancer drug or antibiotic

The conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT) held in Gothenburg (Sweden) in this month (April 11-12) gave an overview on the latest achievements and developments in both diagnostics% and therapy using various laser techniques. The interdisciplinary approach of the conference organized in the frame of Cyclon project (Marie Curie Initial Training Network 237962) by contribution of Center of Skin Research (SkinResQU) of Gothenburg University gave a platform for clinical researchers as well as for chemists and pharmacists. Out of the approx. 40 presentations 14 was related with cyclodextrins covering the following topics [2]:

- multifunctional CD-based nanoconstructs able to produce both singlet oxygen and nitric oxide on the effect of light and providing super-resolution imaging simultaneously;
- nanoparticles such as metal-organic frameworks (MOFs) surface-modified with CD derivatives as proper carriers for azidothimidine model drug;
- self-assembling CDs and CD polymers able to penetrate through biological barriers;
- CD-porphyrin conjugate multimodal drug delivery system of a NO photodonor studied by multiphoton microscopy;
- fluorescent labeling of CD-based nanoconstructs;
- alginate foams containing curcumin complexed with HPBCD or HPGCD;
- supersaturated solutions of curcumin solubilized with various CDs and CD-containing polymers;
- hybrid gold nanoparticles with lactose and BCD as bio recognizable vector for methotrexate delivery to cancer cells.

The CD-assisted photodynamic therapy is a dynamically developing option for anticancer and antimicrobial treatment.

É. Fenyvesi and M. Malanga

References

1. A. R. Morgan, G. B. Garbo, P. Sehker, S. H. Selman (1992) Cyclodextrin for administration of anti-cancer agents. The Sixth International Cyclodextrin Symposium, Chicago, April 21- 24

2. CD related presentations at the 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12:

S. Sortino: Photoactivated nanoconstructs for bimodal phototherapy and super-resolution imaging (S2-KL1 Keynote lecture)

N. Kandoth, V. Kirejev, R. Gref, M. Ericson, S. Sortino: Cyclodextrin based nanoparticles for light controlled nitric oxide release and two-photon fluorescence reporting in cells (S2-3 Oral presentation)

R. Gref: Design and control of drug delivery using nanoparticles (S4-KL1 Keynote lecture)

T. Loftsson: Cyclodextrins as nanocarriers for pharmaceutical applications (S5-KL1 Keynote lecture)

V. Kirejev, R. Goncalves, l. Manet, K. Yannakopoulou, M. B. Ericson: Multiphoton microscopy and spectroscopy of cyclodextrin-porphyrin multimodal drug delivery system (S5-1 Oral presentation)

M. Malanga, L. Jicsinszky, K. Tuza, E. Fenyvesi: Fluorescent labelling of cyclodextrin-based nanoconstructs (S5-2 Oral presentation)

A. B. Hegge, N. Vukicevic, K. O. Wikene, E. Bruzell, H. H. Tonnesen: Supersaturation and supersaturated drug delivery systems to surpass the outer membrane barriers of gram negative bacteria in antimicrobial photodynamic therapy (aPDT) (S6-1 Oral presentation)

H. H. Tonnesen, A. Bee Hegge, E. Bruzell: Application of nanovehicles in preparations for antimicrobial photodynamic therapy (aPDT) (S6-2 Oral presentation)

C. Aggelidou, T. A. Theodossiou, K. Yannakopoulou: Protoporphyrin IX-cyclodextrin conjugate: a nanosized drug carrier and photosensitizer (PS-1 Poster presentation)

A. Aykac, M. C. Martos-Maldonado, J. M. Casas-Solvas, I. Quesada-Soriano, L. Garcia-Fuentes, A. Vargas-Berenguel: Novel B-cyclodextrin-lactose hybrid gold nanoparticle as specific drug delivery system towards cancer cells (PS-2 Poster presentation)

A. Fraix, A. R. L. Goncalves, V. Cardile, A. C. E. Graziano, K. Yannakopoulou, T. A. Theodossiou, S. Sortino: A multifunctional bichromophoric nanoaggregate for imaging and photoactivated therapy of melanoma cells (PS-6 Poster presentation)

R. Anand, F. Manoli, l. Manet, S. Monti, M. P. Donzello, E.Viola, M. Malanga, E. Fenyvesi: Study of the association of a water soluble Zn(ll) porphyrazine octacation to fluorescent cyclodextrin derivatives by spectroscopic techniques (PS-11 Poster presentation)

Y. Wang, B. Cohen, L. Jicsinszky, A. Aykac, A. Vargas-Berenguel, A. Douhal: Second studies of a water-soluble porphyrin derivative in chemical and biological nanocavities: relevance to photodynamic therapy (PS-13 Poster Presentation)

BIBLIOGRAPHY & KEYWORDS

1. CDs: Derivatives, Production, Enzymes, Toxicity

Ni-Ti-layered double hydroxide intercalated with β-CD and CM-β-CD: Interaction between the interlayer guests and the laminates

co-precipitation, XRD, SEM, FTIR, TG-DTG, precursor interlayer,chemical action between Ti–OH and C–OH

Li-Fang Hu, Wei Gao, Jie He, Hong Liu, Bing Li, Xiao-Mei Zhang (2013), Journal of Molecular Structure 1041, 151–155.

Preparation of Branched Cyclomaltoheptaose with 3-O-alpha-L-Fucopyranosyl-α-D-mannopyranose and Changes in Fucosylation of HCT116 Cells Treated with the Fucose-Modified Cyclomaltoheptaose

trichloroacetimidate method, MS, growth-promoting effects

Madoka Kimura, Yuki Masui, Yuko Shirai, Chie Honda, Kenta Moriwaki, Taku Imai, Uichiro Takagi, Takaaki Kiryu, Taro Kiso, Hiromi Murakami, Hirofumi Nakano, Sumio Kitahata, Eiji Miyoshi, Toshiko Tanimoto, (2013), Carbohydrate Research 374, 49–58.

Synthesis and evaluation of novel water-soluble copolymers based on acrylamide and modular β-cyclodextrin

mono-6-(allyl amino)-BCD, mono-2-O-(allyl oxygen radicals-2-hydroxyl propyl)-BCD, acrylamide, acrylic acid, 1-llyl-3-oil acyloxyimidazole-1-ammonion bromide, IR, NMR, SEM, rheometer, XRD

Xiangjun Liu, Wenchao Jiang, Shaohua Gou, Zhongbin Ye, Mingming Feng, Nanjun Lai, Lixi Liang (2013), Carbohydrate Polymers (in press)

An H-shaped polymer bonding beta-cyclodextrin at branch points: Synthesis and influences of attached beta-cyclodextrins on physical properties

PEG, atom transfer radical polymerization, N-isopropylacrylamide, click reaction, glass transition temperature, lower critical solution temperature, nano-sized micelles

Mu, Cheng-Guang, Fan, Xiao-Dong, Tian, Wei, Bai, Yang, Yang, Zhen, Yao, Hao, Chen, Heng (2013), JOURNAL OF POLYMER SCIENCE PART A-POLYMER CHEMISTRY 51, 1405-1416.

Prevalent and persistent Escherichia coli O157:H7 strains on farms are selected by bovine passage

carbohydrate utilization, GCD

Jeong, Kwang Cheol, Hiki, Osamu, Kang, Mm Young, Park, Dongjin, Kaspar, Charles W. (2013), VETERINARY MICROBIOLOGY 162, 912-920.

2. CD complexes: Preparation, Properties in solution and in solid phase, Specific guest

Cyclodextrin-functionalized graphene nanosheets, and their host-guest polymer nanohybrids

solvothermal reduction of graphene oxide, nitrene addition of azido-labeled CD, poly(N-isopropylacrylamide-co-vinylferrocene(II)), ferrocene-modified hyperbranched polyglycerol

Li Q. X., Yon K. Y., Koon-Gee N., En-Tang K., Guo D. F. (2013), Polymer 54, 2264-2271.

Functionalized cyclodextrins bearing an alpha nucleophile – A promising way to degrade nerve agents

chemical scavengers, organophosphorus compounds, paraoxon, cyclosarin

F. Estour, S. Letort, S. Müller, R. K. Kalakuntla, R. Le Provost, T. Wille, G. Reiter, F. Worek, O. Lafont, G. Gouhier (2013), Chemico-Biological Interactions 203, 202 – 207.

Suprarmolecular Hydrogels Driven by the Dual Host-guest Interactions between α-Cyclodextrin and Ferrocene-Modified Poly (ethylene glycol) with Low-Molecular-Weight

host-guest interaction between BCD and ferrocenyl groups, host-guest interaction between ACD and PEG chains

Cheng-Gong Guo, Liang Wang, Ya-Kun Li, Cai-Qi Wang (2013), Reactive and Functional Polymers 73(6), 805–812

UV Light and Temperature Responsive Supramolecular ABA Triblock Copolymers via Reversible Cyclodextrin Complexation

poly(N-(2-hydroxypropyI)methacrylamide), poly(N,N-dimethylacrylamide), poly(N,N-diethylacrylamide), DLS, NOESY, turbidity

Schmidt, Bernhard V. K. J., Hetzer, Martin, Ritter, Helmut, Barner-Kowollik, Christopher (2013), MACROMOLECULES 46, 1054-1065.

Photo-responsive pseudo[n]rotaxanes based on disparate hetero-macrocycle host combination

ACD, cucurbit[7], p-sulfonatocalix[4]arene, MALDI-TOF MS, NMR, UV-vis

Sun, Ruyi, Ma, Xiang (2013), TETRAHEDRON 69, 1069-1073.

Preferential Adhesion of Silver Nanoparticles Onto Crystal Faces of alpha-Cyclodextrin / Carboxylic Acids Inclusion Compounds

stabilized shell of the nanoparticles by COOH groups, crystalline coating, octanoic and decanoic acid

Rodriguez-Llamazares, S., Jara, P., Yutronic, N., Noyong, M., Fischler, M., Simon, U. (2013), JOURNAL OF NANOSCIENCE AND NANOTECHNOLOGY 12, 8929-8934.

3. CDs in Drug Formulation

Photoactivated nanoconstructs for bimodal phototherapy and super-resolution imaging

porphirin, NO-releasing agent, fluorescent nanoscopy

Salvatore Sortino, 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12, 2013, S2-KL1 Keynote lecture

Cyclodextrin based nanoparticles for light controlled nitric oxide release and two-photon fluorescence reporting in cells

cancer cells, two-photon fluorescence

Noufal Kandoth, Vladimir Kirejev, Ruxandra Gref, Marica Ericson, Salvatore Sortino, 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12, 2013, S2-3 Oral presentation

Design and control of drug delivery using nanoparticles

metal-organic frameworks (MOFs), modified by CDs, engineered nano-MOFs, azidothimidine

Ruxandra Gref, 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12, 2013, S4-KL1 Keynote lecture

Cyclodextrins as nanocarriers for pharmaceutical applications

skin surface, hair follicles, eye surface, retina

Thorsteinn Loftsson, 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12, 2013, S5-KL1 Keynote lecture

Multiphoton microscopy and spectroscopy of cyclodextrin-porphyrin multimodal drug delivery system

solubility and stability, penetration into the skin, combining photodynamic therapy with chemotherapy

Vladimir Kirejev, Ricardo Goncalves, Ilse Manet, Konstantina Yannakopoulou, Marica B. Ericson, 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12, 2013, S5-1 Oral presentation

Fluorescent labelling of cyclodextrin-based nanoconstructs

HPBCD, carboxymethyl-BCD, RAMEB, rhodaminyl-, fluoresceinyl-, nitro-benzofurazanyl and coumarinyl-CD derivatives

Milo Malanga, Laszlo Jicsinszky, Kata Tuza, Eva Fenyvesi, 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12, 2013, S5-2 Oral presentation

Supersaturation and supersaturated drug delivery systems to surpass the outer membrane barriers of gram negative bacteria in antimicrobial photodynamic therapy (aPDT)

E.coli, nanocarriers, PEG, PEG-CD polymers, MeBCD

A. B. Hegge, Nl. Vukicevic, K. O. Wikene, E. Bruzell, H.H. Tonnesen, 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12, 2013, S6-1 Oral presentation

Application of nanovehicles in preparations for antimicrobial photodynamic therapy (aPDT)

alginate foams, curcumin, HPBCD, HPGCD, sterilization

Hanne Hjorth Tonnesen, Anne Bee Hegge, Ellen Bruzell, 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12, 2013, S6-2 Oral presentation

Protoporphyrin IX-cyclodextrin conjugate: a nanosized drug carrier and photosensitizer

5-aminolevulinic acid, tamoxifen, phototoxicity

Chrysie Aggelidou, Theodossis A. Theodossiou, Konstantina Yannakopoulou, 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12, 2013, PS-1 Poster presentation

Novel beta-cyclodextrin-lactose hybrid gold nanoparticle as specific drug delivery system towards cancer cells

bio recognizable vector, lectins, methotrexate

Ahmet Aykac, Manuel C. Martos-Maldonado, Juan M. Casas-Solvas, Indalecio Quesada-Soriano, Luis Garcia-Fuentes, Antonio Vargas-Berenguel, 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12, 2013, PS-2 Poster presentation

A multifunctional bichromophoric nanoaggregate for imaging and photoactivated therapy of melanoma cells

porphyrin covalently bound with BCD, nitric oxide photodonor, nanoassembly, singlet oxygen and nitric oxide

A. Fraix, A. R. L. Goncalves, V. Cardile, A. C. E. Graziano, K. Yannakopoulou, T. A. Theodossiou, S. Sortino, 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12, 2013, PS-6 Poster presentation

Study of the association of a water soluble Zn(II) porphyrazine octacation to fluorescent cyclodextrin derivatives by spectroscopic techniques

carboxymethyl-BCD, nitro-benzofurazan-triazolyl chromophore, carboxymethyl-BCD-epichlorohydrin crosslinked oligomer, rhodaminyl moiety

R.Anand, F.Manoli, I.Manet, S.Monti, M.P.Donzello, E.Viola, M.Malanga, E.Fenyvesi, 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12, 2013, PS-11 Poster presentation

Second studies of a water-soluble porphyrin derivative in chemical and biological nanocavities: relevance to photodynamic therapy

quaternary ammonium modified BCD, hexa-2,4-diynediyl briged BCD dimer, human serum albumin, singlet oxygen, stopped-flow spectrometer

Yilun Wang, Boiko Cohen, Laszlo Jicsinszky, Ahmet Aykac, Antonio Vargas-Berenguel, Abderrazzak Douhal, SO 1st Conference on „Application of Nanodrugs in Photodynamic Therapy" (NanoPDT), Gothenburg (Sweden), April 11-12, 2013, PS-13 Poster Presentation

4. CDs in Cell Biology

Gene silencing of TNF-alpha in a murine model of acute colitis using a modified cyclodextrin delivery system

cytokine, siRNA, macrophage, PCR, IL-6

J. McCarthy, M. J. O'Neill, L. Bourre, D. Walsh, A. Quinlan, G. Hurley, J. Ogier, F. Shanahan, S. Melgar, R. Darcy, C. M. O'Driscoll (2013), Journal of Controlled Release 168, 28–34

Cationic nanoparticles disrupt cellular signaling in a cholesterol dependent manner

charged polystyrene, IL-8 gene expression, IL-6, IL-8, NF-κB, membrane cholesterol integrity

Chia T. Thach, Jacob N. Finkelstein (2013), Toxicology in Vitro 27, 1277–1286

Discovery of Oxysterol-Derived Pharmacological Chaperones for NPC1: Implication for the Existence of Second Sterol-Binding Site

polytopic endosomal membrane protein, mutation, intracellular cholesterol accumulation, oxysterol derivatives

Kenji Ohgane, Fumika Karaki, Kosuke Dodo, Yuichi Hashimoto (2013), Chemistry & Biology 20, 391-402

Folic Acid Modified Cationic gamma-Cyclodextrin-oligoethylenimine Star Polymer with Bioreducible Disulfide Linker for Efficient Targeted Gene Delivery

bioreducible disulfide bond, KB cells, A549 cells, cationic polymers, cytotoxicity, endocytosis

Zhao, Feng, Yin, Hui, Zhang, Zhongxing, Li, Jun (2013), BIOMACROMOLECULES 14, 476-484

Mechanisms underlying the inhibition of murine sperm capacitation by the seminal protein, SPINKL

in vitro capacitation-enhancing agents, methyl-BCD

Tseng, Huan-Chin, Lee, Robert Kuo-Kuang, Hwu, Yuh-Ming, Lu, Chung-Hao, Lin, Ming-Huei, Li, Sheng-Hsiang (2013), JOURNAL OF CELLULAR BIOCHEMISTRY 114, 888-898.

Modular Multifunctional Poly(ethylene glycol) Hydrogels for Stem Cell Differentiation

functional CD nanobeads threaded onto poly(ethylene glycol) (PEG) polymer necklaces

Singh, Anirudha, Zhan, Jianan, Ye, Zhaoyang, Elisseeff, Jennifer H. (2013), ADVANCED FUNCTIONAL MATERIALS 23, 575-582.

5. CDs in Food, Cosmetics and Agrochemicals

Retention of aroma compounds from Mentha piperita essential oil by cyclodextrins and crosslinked cyclodextrin polymers

menthol, menthone, pulegone, eucalyptol, static headspace gas chromatography

Ciobanu, A., Mallard, I., Landy, D., Brabie, G., Nistor, D., Fourmentin, S. (2013), FOOD CHEMISTRY 138, 291-297.

Permethylated beta-cyclodextrin/pesticide complexes: X-ray structures and thermogravimetric assessment of kinetic parameters for complex dissociation

TRIMEB, fenitrothion, fenthion, acetochlor, isothermal and non-isothermal thermogravimetry

Cruickshank, Dyanne L. and Rougier, Natalia M., Maurel, Vaughan J., de Rossi, Rita H., Bujan, Elba I., Bourne, Susan A., Caira, Mino R. (2013), JOURNAL OF INCLUSION PHENOMENA AND MACROCYCLIC CHEMISTRY 75, 47-56.

6. CDs for other Industrial Applications

Cotton-made cellulose support for anti-allergic pajamas

monochlorotriazinyl-BCD, Viola tricolor, propolis, menthol, advantan, hydrocortisone, pimechrolimus, anti-microbial activity, dermatitis

Cezar-Doru Radu, Mihaela Salariu, Manuela Avadanei, Cristina Ghiciuc, Lili Foia, Elena Cătălina Lupusoru, Ada Ferri, Eugen Ulea, Florin Lipsa (2013), Carbohydrate Polymers 95, 479-486

Removal of Azo Dyes from Water by Combined Techniques of Adsorption, Desorption, and Electrolysis Based on a Supramolecular Sorbent

Congo red, SiO2-CD, BCD, HPBCD, desorption agent

Chen, Ming, Ding, Wenhua, Wang, Jing, Diao, Guowang (2013), INDUSTRIAL & ENGINEERING CHEMISTRY RESEARCH 52, 2403-2411.

Synthesis and electro-optical properties of polyfluorene modified with randomly distributed electron-donor and rotaxane electron-acceptor structural units in the main chain

9,9-dioctylfluorene, methyltriphenylamine, 9-dicyanomethylenefluorene complexed with CD, fluorescence, aggregation

Farcas, Aurica, Janietz, Silvia, Harabagiu, Valeria, Guegan, Philippe, Aubert, Pierre-Henri (2013), JOURNAL OF POLYMER SCIENCE PART A-POLYMER CHEMISTRY 51, 1672-1683.

Syntheses of Metallic Cyclodextrins and Their Use as Synergists in a Poly(Vinyl Alcohol)/Intumescent Flame Retardant System

thermal stability, initial decomposition, temperature, SEM, FTIR, X-ray photoelectron spectroscopy

Feng, Jianxiang, Zhang, Xiaomin, Ma, Songqi, Xiong, Zhu, Zhang, Chuanzhi, Jiang, Yanhua, Zhu, Jin (2013), INDUSTRIAL & ENGINEERING CHEMISTRY RESEARCH 52, 2784-2792.

Fabrication of beta-cyclodextrin conjugated magnetic HNT/iron oxide composite for high-efficient decontamination of U(VI)}

halloysite nanotube, XRD, sorption reversibility

Yang, Shitong, Zong, Pengfei, Hu, Jun, Sheng, Guodong, Wang, Qi, Wang, Xiangke (2013), CHEMICAL ENGINEERING JOURNAL 214, 376-385.

Carbonyl-beta-Cyclodextrin as a Novel Binder for Sulfur Composite Cathodes in Rechargeable Lithium Batteries

bonding strength, solubility, viscosity, electrochemical windows

Wang, Jiulin, Yao, Zhendong, Monroe, Charles W., Yang, Jun, Nuli, Yanna (2013), Advanced Functional Materials 23, 1194-1201.

7. CDs in Sensing and Analysis

Capillary electrophoresis with capacitively coupled contactless conductivity detection for the determination of cis/trans isomers of octadec-9-enoic acid and other long chain fatty acids

lauric, myristic, tridecanoic, pentadecanoic, palmitic, stearic, oleic, elaidic, linoleic, linolenic and arachidic acids, TRIMEB

Yong Foo Wong, Bahruddin Saad, Ahmad Makahleh (2013), Journal of Chromatography A 1290, 82–90.

Application of cyclodextrin-modified gold nanoparticles in enantioselective monolith capillary electrochromatography

chlorpheniramine, zopiclone, tropicamide

Min Li, Musa Tarawally, Xi Liu, Xiaoling Liu, Liping Guo, Li Yang, Guang Wang (2013), Talanta 109, 1–6.

Application and comparison of high performance liquid chromatography and high speed counter-current chromatography in enantioseparation of (+/-)-2-phenylpropionic acid

high speed counter-current chromatography, HPBCD

Tong, Shengqiang, Zheng, Ye, Yan, Jizhong (2013), JOURNAL OF CHROMATOGRAPHY A 1281, 79-86.

Semi-Preparative Enantiomeric Separation of Ofloxacin by HPLC

mono (6A-azido-6A-deoxy)-per(p-chlorophenyl carbamoylated) BCD chiral stationary phase

Fang, Zhili, Guo, Ziyuan, Qin, Qing, Fan, Jun, Yin, Yong, Zhang, Weiguang (2013) JOURNAL OF CHROMATOGRAPHIC SCIENCE 51, 133-137.

Characterization of Volatile Components of Zingiber roseum Essential Oil Using Capillary GC on Modified Cyclodextrins

6-tert-butyldimethylsilyl-2,3-diethyl-BCD, 2,3,6-methyl-BCD, (1R)-(+)-alpha-pinene, (1R)-(+)-beta-pinene, (R)-(+)-limonene

Pragadheesh, VPPalayam S., Yadav, Anju, Singh, Manju, Chanotiya, Chandan S. (2013), NATURAL PRODUCT COMMUNICATIONS 8, 221-224.

Determination of antioxidant activity using oxidative damage to plasmid DNA - pursuit of solvent optimization

HPBCD, co-solvent

Treml, Jakub, Smejkal, Karel, Hosek, Jan, Zemlicka, Milan (2013) CHEMICAL PAPERS 67, 484-489.

Cyclodextrin Inclusion Interferes with Trolox Oxygen Radical Scavenging Capacity Measurement

oxygen radical scavenging capacity assay, ORAC methods, NMR

Sueishi, Yoshimi, Ishikawa, Misa, Hori, Masashi, Inazumi, Naoya (2013) ZEITSCHRIFT FUR PHYSIKALISCHE CHEMIE-INTERNATIONAL JOURNAL OF RESEARCH IN PHYSICAL CHEMISTRY & CHEMICAL PHYSICS 227, 49-55.

Edited and produced by: CYCLOLAB
Homepage:www.cyclolab.hu
H-1525 P.O. 435, Budapest, Hungary
Tel:(361) 347-6060
Fax: (361) 347-6068
e-mail: cyclolab@cyclolab.hu