List of Available Technologies* at National Chemical Laboratory, Pune

(Ready to be Licensed/Looking for a Startup Partner)



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*This is only a partial list of available technologies, for further details, please visit our website www.nclinnovations.org or contact our case manager at Tel: (+91) 020 2590 2982

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List of Technologies by Portfolio

Case#	Title
	Polymers, Materials, Chemicals
001	Value added chemicals from Cashew Nut Shell Liquid(CNSL)
002	Titanium dioxide Nanoneedles with applications in paints, coatings, photo-catalyst
003	Gel-o-Fuel: A polymer gel that absorb organic liquids/fuels/alcohol for use as fuel in hospitality, catering, travel, interior decoration
005	Membrane for purification of NEERA (palm sap) for longer shelf life
008	PU Microcapsules encapsulating pesticides, biocides, disinfectants etc.
009	Membranes for producing oxygen enriched air for medical applications
009	Membranes for gas separation for industrial uses
009	Membranes for aroma recovery, alcohol dehydration, recovery of nonvolatile acids
015	Nanoparticle-polymer complex for sustained release of oral care products
016	Self standing nanoparticle networks/scaffolds with applications in catalysis, electronics, etc.
022	A single-step process for the preparation of highly pure alkyl esters used in making lactic acid, poly lactic acid
024	Slow release hydrogel system for nutrient (small molecules) delivery to recombinant cell lines
028	A novel process for making monomer used in producing Polybenzimidazole (PBI)- a specialty/ engineering
	polymer
006	Pharmaceutical, Drugs, Delivery, Formulation
006	Lactide macromer based conclumer used in taste masking of drugs
010	New Target & Drug Molecule for Cancer, Type II Diabetes
011	New Process for Preparation of Copolymer-1, used in Treatment of Multiple Sclerosis
013	A Library of New Small Molecules that could be used as Anticancer, Antiviral Drugs
014	A new method to synthesize anti malarial drug and its analogues
016	Self standing nanoparticle networks/scaffolds with applications in drug delivery, tissue engineering etc.
018	Injectable biodegradable gels with hydrophobic pockets/cavity for delivery of drugs
019	Continuous flow synthesis of sulphoxide compounds for use in drug formulations
020	Process for the continuous flow synthesis of ß-amino crotonate (for use in anti-hypertensive drugs)
035	New Chemical Entities (NCE) for treatment of malaria and CNS disorders
012	Biomaterials from Regenerated Silk Fibroin
012	Self standing nanonarticle networks/scaffolds with annlications in tissue engineering etc
017	Nanogold-Loaded Sharp-Edged Carbon Bullets as Gene Carriers
018	Injectable biodegradable gels with hydrophobic pockets/cavity for tissue engineering, biomedicine etc.
024	Slow release hydrogel system for nutrient (small molecules) delivery to recombinant cell lines
034	Modified Porous Polymers with Enhanced Biocompatibility for Implants and Tissue Engineering Applications
	Water Treatment
004	A mechanical process that kills microorganisms at required levels: for treating ballast water in ships,
	Instrumentation
007	An in-situ Quartz Crystal Microbalance (QCM) that can be used for molecular recognition in scientific research
021	Low energy consuming novel impeller for stirred tank reactors
041	Novel silica based substrate (SBA15) for efficient small molecules analysis in mass spectrometry
	Coatings, Paints
002	Titanium dioxide Nanoneedles with applications in paints
800	PU Microspheres/Microcapsules for coatings

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	Biomass Value Addition
001	Value added chemicals from Cashew Nut Shell Liquid(CNSL)
029	Process yielding high value fuel additives (octane enhancers) from lignin
031	Single step process for making high-value chemicals like xylose and arabinose from hemicellulose

Value added chemicals from Cashew Nut Shell Liquid (CNSL)

EXECUTIVE SUMMARY

Value added chemicals (specialty monomers and polymers) from cashew nut shell liquid that have wide ranging industrial and consumer applications

TECHNOLOGY DESCRIPTION

A range of difunctional monomers (dihalides, diacids, diisocyanates, diamines, diacyl hydrazides, diphenols, dialdehydes etc.) and polymer additives are produced utilizing 3pendadecyl phenol derived from cashew nut shell liquid (CNSL) using NCL's technology. A host of high-performance polymers (polyimides, polyamides, polyesters, poly(amide-imide)s etc.) can be prepared using the difunctional monomers mentioned above.

MARKET POTENTIAL

- There is significant margins involved in producing value added chemicals from CNSL
- CNSL sells for about \$500/ton whereas, Cardanol a CNSL constituent, when separated sells for over \$3000/ton*
- India exports close to 10,000 tons of CNSL a year** - abundant availability of raw materials
- CNSL production capacity in India over 20,000 tons/year

*H. S. Couto1, J.B. F.Duarte1 and D. Bastos-Netto, Biomass Combustion Chamber for Cashew Nut Industry, The Seventh Asia-Pacific International Symposium on Combustion and Energy Utilization`December 15-17, 2004, **http://www.cashewindia.org/

VALUE/ADVANTAGES

- High performance polymers produced from CNSL have improved processability characteristics
- Produced from low cost raw materials that are widely available in India
- Sustainable, renewable source

APPLICATIONS

- Thickeners in paints, cosmetics, oils, food and textiles
- Electrical insulating varnishes
- Enamels & adhesives
 - Auto brake lining
 - Substitute for linseed oil (in manufacturing foundry core oil, which is used as a binder)
 - Cement hardening agent
 - Used in lamination industry (for reduced brittleness and improved flexibility)
 - Epoxy resins & rubber compounding resins

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners for spinoff and licensing
- Patents granted: US <u>7,572,863</u>, US <u>7,446,234</u>, US <u>7,297,822</u>, US <u>7,709,687</u>, IN<u>242391</u>, IN<u>231770</u>



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Titanium dioxide nanoneedles

EXECUTIVE SUMMARY

A simple one step process for producing pure rutile titanium dioxide nanoneedles at room temperature with high aspect ratio and high morphology control. Potential applications in paints, coating, as photo catalysts, etc.

BACKGROUND

Titanium dioxide (TiO_2) occurs in nature as rutile, anatase and brookite. Rutile is the most common and most stable form and has wide ranging applications. Producing pure rutile TiO_2 has been very time-consuming or cost-intensive or both. Also, it was very difficult to control the morphology of the resulting product.

TECHNOLOGY DESCRIPTION

NCL's technology involves a one-step electrochemical process for the synthesis of pure rutile TiO_2 nanoneedles, with high aspect ratio, at room temperature. Nanoneedles with aspect ratio of ≥ 10 can be produced with very good control over the morphology of the resulting TiO_2

MARKET POTENTIAL

- Large market potential with high growth rates- TiO₂ market is expected to top \$2.3 billion by 2012** and annual growth rate in India is expected to be around 8-10%*
- Nano-TiO₂ sells at a very high premium over bulk TiO₂; Nano-TiO₂ is sold anywhere between \$176 to \$198/kg ***
- Raw titanium ores currently trade between \$0.09 and \$0.51/kg,
- Processed bulk TiO_2 trades at approximately 2.21/kg

• Increasingly, more and more nano- TiO₂ is expected to be used in place of bulk TiO₂

* http://www.icis.com/v2/chemicals/9076546/titanium-dioxide/uses.html, ** http://www.nanotech-now.com/news.cgi?story_id=30032, *** Estimates of Upper Bounds and Trends in Nano-TiO2 Production As a Basis for Exposure Assessment, Environ. Sci. Technol., 2009, 43 (12), pp 4227–4233

VALUE/ADVANTAGES

- Less energy intensive (process carried out at room temperature)
- Ability to synthesize phase-pure rutile TiO2
- Reduced time for synthesis (as this process avoids any formation of intermediate amorphous powder or anatase phase and hence doesn't need heat treatment to from rutile TiO2)
- Easier, cheaper, quicker process (when compared to previous methods of synthesis)

APPLICATIONS

Rutile TiO2 is widely used as/in

- UV protecting agent
- In optical coatings
- Beam splitters
- Anti-reflection coating
- Humidity sensor
- High-temperature oxygen sensor
- Photo-catalyst
- Biomedicine

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners for spinoff and licensing
- Patent applications filed: Indian #-0049/DEL/2009; PCT #- IN2010/000022



Gel-o-fuel

EXECUTIVE SUMMARY

Polymer based gels, that can absorb organic liquids and fuels, and can be used as a portable fuel source in catering/hospitality industry, camping, travelling and for interior decoration (fireplaces, etc.)

TECHNOLOGY DESCRIPTION

NCL scientists have developed a polymer based gel that can absorb organic solvents like methanol, ethanol etc. and can act as a portable fuel source. The gel can be polymerized in situ from the selected monomers and does not require any external gelling agent. The level of cross linking and the formation of structural complexes with the organic liquid can be controlled - improving the absorption capacity of the gel. 1gm of this gel can absorb upto 400 gm of fuel.

MARKET POTENTIAL

- The hospitality industry at a high growth, to meet the current demand, has to more than double in size*
- Indian catering industry is worth over Rs. 57,000 Crore, with high growth rate**
- Gel-o-Fuel has great potential to be used as a portable fuel source for catering, travel and other purposes.

*http://www.business-standard.com/india/news/kit-hotels-inindiademandsupply/351939/ ** PROCESSED FOOD INDUSTRY. Jul 31, 2007; pg 14

VALUE/ADVANTAGES

- Effective, flexible, compact source of fuel
- No soot, pleasant blue flame
- Higher burning efficiency
- Existing gels use a commercial polymer (expensive); Gel-o-fuel uses cheaper, easily available raw-materials
- Liquids that is trapped in the 3D matrix of the gel is turned in to soft solids-easy and safe to transport

APPLICATIONS

- ➢ Solid fuel
- Fireplaces
- Patio/garden/yard burners
- Outdoor cooking
- Camping/travel/guest houses/hotels
- Chafing dish fuel
- Catering
- Cooking

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners for licensing
- Patent granted: US <u>6,794,467</u>



Ballast water treatment

EXECUTIVE SUMMARY

A mechanical process (based on hydrodynamic cavitation) which can be used to kill microorganisms and purify ballast water released from ships. Also could be used to produce drinking water from a contaminated source.

BACKGROUND

Ships when leaving the port empty, take seawater into ballast tanks for stability and to adjust buoyancy. When the ballast water is emptied at a different location, it releases microorganisms into the location, causing environmental pollution and ecological imbalance

TECHNOLOGY DESCRIPTION

NCL scientists have developed an apparatus which can filtrate and disinfect sea water/ ship's ballast water. It is based on a mechanical process that kills micro-organisms to the required levels, using hydrodynamic cavitation and rupture of cavities to kill micro-organisms. They can also be used in making potable drinking water from a contaminated source.

MARKET POTENTIAL

- Annual market for Ballast Water Treatment is estimated to be between \$700 million to \$1 billion (in the short term, while all the current vessels are being fitted with this technology)
- More than 17,000 vessels (both new and retrofit) can be fitted with this technology
- Long term market projected to be between \$200 to \$300 million (which will be mostly on newly built vessels)

* All data derived from Haskoning Report, 2001

VALUE/ADVANTAGES

- Eco-friendly as using hydrodynamic cavitations without using any chemicals, UV or ultrasound
- No harmful by-products
- Efficient disinfection technology
- One of the best alternatives to current technology
- Economical
- Easily installed on the vessel- minimum area for installation as filtration and disinfection happen in a single equipment

APPLICATIONS

- Sea water treatment
- Ship's ballast water treatment
- Making potable drinking water from a contaminated source

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- Ready to be licensed
- Patent granted: US #- 7815810, 7585416



CSIR-National Chemical Laboratory, Pune, India

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NREP/Taste Masking in drugs

EXECUTIVE SUMMARY

A new reverse enteric polymer responsive to changes of pH – which can be used for taste masking of drugs. Can also be used in designing custom release profiles.

TECHNOLOGY DESCRIPTION

New Reverse Enteric Polymer (NREP) is a cationic ter-polymer which is responsive to changes in pH. It is hydrophobic and hence insoluble in water. Their main use would be for taste making of drugs and designing custom release profiles in drug formulations.

MARKET POTENTIAL

- Global market for excipient chemicals will be worth \$4.3 billion by 2011*
- Oral drug delivery market is poised to grow at 10% per annum to reach the \$50 billion mark by 2010**
- Novel drug delivery methods are being sought after to develop novel products and maintain market leadership and profits**
- Large pharma companies are looking to partner with drug delivery companies** with niche technology – making it ideal to develop NREP products

VALUE/ADVANTAGES

- Taste masking of solid dosage forms and liquid orals
- High Tg (121°C) easier to process and cure
- Enhances biocompatibility
- Could be used to custom sustained release of drugs
- Avoids adverse drug-polymer interactions
- Rapid release at gastric pH
- Inhibits polymorphism in drugs
- More stable dosage forms

APPLICATIONS

- Use as excipient
- Delivery of drugs
- Taste masking
- Coatings for moisture barrier, sustained release and rapid release
- Polymorphism inhibition

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners for licensing
- Patents granted: Indian, US7294347



^{**}http://www.prlog.org/10042410-world-market-for-excipient-chemicals-willreach-4-3-billion-by-2011-says-new-report.html, ** http://www.inpharmatechnologist.com/Materials-Formulation/Oral-drug-delivery-sector-tippedfor-explosive-growth

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Quartz Crystal Microbalance (QCM)

EXECUTIVE SUMMARY

An in situ quartz crystal microbalance (QCM), based on a compact embedded system, that can be used to study molecular recognition and for other scientific/ research purposes

TECHNOLOGY DESCRIPTION

An in-situ QCM that can be used for molecular recognition in advanced scientific research has been described. The system has a wide and continuous range of frequencies, up to 30 MHz. It can be used to make continuous real time measurements up to microsecond levels. The system also has an "embedded, system-on-chip software", with hard-to-copy software and could be made portable.

MARKET POTENTIAL

- QCMs will be widely used in any materials/bio/pharma/nano-tech R&D facilities- there are over 2400 R&D facilities in India* - with a large portion of them requiring new instruments, and hence offering new markets
- Production of instrumentation related products in India was estimated at Rs.50 billion per annum**- analytical instruments market alone has been growing at over 10% per annum
- More and more R&D centers are being set-up in India, with MNC's joining the fray– great potential for growth in instrumentation sector

*DSIR Directory of SIROs, In-house R&D units, registered R&D institutions, ** Report on "The Engineering Sector in India"", July 2008, pub. By Indo-Italian Chamber of Commerce and Industry

VALUE/ADVANTAGES

- Compact system could be made portable
- A range of frequencies is possible- thus enabling a variety of measurements with a single instrument
- Avoids complicated design requirements by using a
- System-on-a-chip (SOC) system
- Continuous monitoring of experiments possible- thus increasing the utility and flexibility
- Low cost alternative to imported instruments

APPLICATIONS

- Widespread use in research laboratories
- For probing surface level changes, molecular recognition etc.
- Used by researchers in the areas of: Nano-science, biotechnology, polymers, electrochemistry etc.

TECHNOLOGY STATUS

- Working prototype has been successfully demonstrated at the lab scale
- On the lookout for potential partners for licensing



Polyurethane (PU) microspheres & microcapsules

EXECUTIVE SUMMARY

Spherical PU microspheres of uniform shape and size used in getting a film of uniform thickness without any defects or fat edges. Applications in coatings, paints, powder coating/molding. Also, PU microcapsules that can encapsulate any chemical of interest, that could be later released when required.

TECHNOLOGY DESCRIPTION

A novel process for preparation of polyurethane microspheres of uniform shape, a narrow particle size distribution, size ranging from 1 to 100 micron and molecular weight ranging from 200-2000. The yield is as high as \sim 60-85%.

A process for the preparation of polyurethane microcapsules that can encapsulate any chemical of interest, that could be later released when required. For ex.: biocides, pesticides, anti-microbial agents, disinfectants, etc.

MARKET POTENTIAL

- Indian paint industry has been growing at 13% over the last five years & predicted to grow by 15% annually over the next five years*
- Asia Pacific paint market is expected to grow by 7.9% per year, and top demand over 20 million tons by 2014**
- Powder coatings are increasingly being used to meet the needs of new markets/ applications and the worldwide powder coating market in 2010 was \$ 2.5 billion^
- The market for anti-microbial coatings in the US has been projected to touch \$ 1 billion by the year 2015##

* Coatings World, May, 2008, **http://www.coatingsworld.com/contents/view/24989 ^www.malvern.com/ProcessEng/industries/powder_coatings/overview.html##www.p rweb.com/releases/anti_microbial_coatings/indoor_air_quality/prweb8121153.htm

VALUE/ADVANTAGES

- > Microspheres
- Produces a film or coating of uniform thickness without defects or fat edges
- Narrow particle size distribution
- Superior appearance (smoothness, uniform coating thickness)
- ➢ Microcapsules
- Reduce the environmental/mammalian toxicity otherwise caused
- Controlled Release by microcapsules extends the activity of the agent increases effective delivery, and longer life

APPLICATIONS

- Microspheres
- Coatings, paints an powder molding
- Adhesives
- As an encapsulant for pigments, agrochemicals, drugs and reactive chemicals like curing agents
- ➢ Microcapsules
- Controlled release applications in interior/ exterior paints, coatings for medical devices,for example, biocides, fungicides or algaecides

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners for licensing
- Patent applications filed/granted: US <u>5814675</u>, US <u>5859075</u>, US <u>5962003</u>, US <u>6123988</u>, US <u>6239213</u>, US <u>20060251688A1</u>



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Membranes for gas/liquid separation

EXECUTIVE SUMMARY

Thin film composite membranes that are used for gas separation and also for pervaporation for aroma recovery. Uses include producing oxygen enriched air for medical applications and other medical and industrial uses.

TECHNOLOGY DESCRIPTION

A method for preparation of aromatic polyester based membranes from readily available raw materials by conventional methods, with high yield is described. These membranes can be used for separating various gases (e.g., hydrogen from methane, helium from nitrogen, oxygen from nitrogen etc.) A method for preparation of PDMS based thin film composite membranes that can be used for pervaporation/perstraction.

MARKET POTENTIAL

- The worldwide market demand for membranes has been predicted to reach \$15 billion in 2012, growing at the rate of 8.6% annually*
- Global oxygen concentrator market has been valued at \$1.2 billion in 2011 and further growth predicted^- illustrating the potential for use of membranes in this market
- Membranes have great potential to be used in the flavor and fragrance industry- which in 2010 had revenues of over \$20 billion, and has a high growth rate**

*World Membrane Separation Technologies Industry Study with Forecasts for 2012 & 2017, Study #2468, April 2009, Page 393- Freedonia, ^Oxygen Concentrator Market Opportunities, Strategies, and Forecasts, 2005 - 72011, Winter Green Research Inc., Dec 2005, Page 122, **http://www.leffingwell.com/top_10.htm

VALUE/ADVANTAGES

- Gas separation membranes
- Made from readily available raw materials, conventional methods of preparation (low cost), with high yield
- Can be easily processed (the polymers used are soluble in common solvents)
- Possess a very good combination of gas selectivity and permeability
- Very stable at high temperatures
- Pervaporation(alcohol dehydration, aroma recovery) /Perstraction (recovery of nonvolatile acids) membranes
- High fluxes, high selectivity
- Operational simplicity
- Low energy requirements

APPLICATIONS

- O₂/N₂ enrichment (medical applications), biogas processing, H₂ recovery (hydroprocessing purge systems, ammonia & petrochemical plant), synthesis gas (H₂/CO) ratio adjustment
- Aroma recovery in perfume industry/ fragrance and flavor separation in food industry
- Removal of organics from water, water from organics, organic / organic separation
- Separation of acids (organic and inorganic) from complex mixtures like fermentation broths

TECHNOLOGY STATUS

- Demonstrated at the lab scale/prototype demo-ed for O₂ enrichment for medical appl.
- Ready to be licensed
- Patent granted: US # <u>6420511 B1</u>



New drug target & promising chemical starting point for treating cancer, type 2 diabetes

EXECUTIVE SUMMARY

A new therapeutic strategy that identifies a new drug target and development of various promising small molecules that show promising results in animal testing to be further developed into drugs for treatment of cancer and type II diabetes.

BACKGROUND

PI3-kinase (PI3K) pathway is a crucial set of reactions that occurs at the cellular level. Misregulation of this pathway plays an important role in causing cancer and type II diabetes and hence offers promising targets for developing drugs to combat these diseases. Conventional therapeutic strategies have targeted inhibiting downstream targets in this pathway, and have not concentrated on targeting protein-lipid interactions.

TECHNOLOGY DESCRIPTION

Our technology looks at identifying a new strategy and potential drug molecules that target lipid-protein interactions (PIP3/protein binding) as a therapeutic tactic. We have also developed promising chemical leads (small molecule antagonists for PIP3/protein binding) – which inhibit cancer cell survival, resulting in significant antitumor activity in vivo as well as a set of small molecule non-lipid antagonists of lipid-protein interactions, which can be used to design specific drugs

MARKET POTENTIAL

- The world targeted cancer drug market is predicted to reach \$51 billion by 2015*
- The combined market globally for diabetes type 2 diagnostics and therapeutics has been

predicted to reach \$242 billion by the year 2013 at a growth rate of 2.5% a year^

*http://www.thepharmaletter.com/file/45882/targeted-cancer-drug-market-set-to-reach-51-billion-by-2015-led-by-pfizer-barriers-to-use-of-oral-cancer-drugsidentified.html -viewed 16/05/11, ^http://www.bccresearch.com/report/diabetestherapies-diagnostics-hlc029b.html -viewed 19/05/11

VALUE/ADVANTAGES

- Can selectively inhibit PIP3-mediated signaling
- Found to be able to target a wide range of PIP3-dependent signaling events in vitro
- Significant anti-tumour activity in vivo
- Exhibit improved activity /PH domain selectivity compared to previously identified antagonists
- Promising chemical starting points that have been optimized, that have undergone successful animal trials

APPLICATIONS

• New therapeutic strategies and development of small molecules that can serve as promising chemical leads in developing new drugs for the treatment of cancer and type II diabetes

TECHNOLOGY STATUS

- Demonstrated at the lab scale (animal studies conducted using the small molecules developed – with promising results; various small molecules have been tested and optimized)
- On the lookout for potential partners for spinoff and licensing (This technology was jointly developed by NCL, Pune and Tufts University, USA)
- Patent application filed- US



Process for Preparation of Copolymer-1-used in the treatment of multiple sclerosis

EXECUTIVE SUMMARY

A novel process for the synthesis of Copolymer-1 and its pharmaceutically acceptable salts, which is used in the treatment of Multiple Sclerosis (MS). This process yields precisely tailored, non-toxic end products with readily available raw materials at a much reduced cost.

BACKGROUND

Out of the many processes available today for synthesis of Copolymer- 1, no process provides control over the specific molecular weight (m. wt.) especially since the m.wt of 22KDa and above is considered toxic and without residual levels of acids.

TECHNOLOGY DESCRIPTION

A novel process using readily available raw materials, for the synthesis of Copolymer-1 and its pharmaceutically acceptable salts is described here. The process uses a polymer bound catalyst as an initiator (which requires 10X less catalyst concentration than conventional systems). The resulting polymer has a narrow molecular weight distribution, with m.wt can be tailored to be in the range of 8-19KDa. Copolymer-1 could be injected subcutaneously, intra-peritoneally, intravenously, intramuscularly for the treatment MS.

MARKET POTENTIAL

- Over 2.5 million people suffer from MS worldwide*
- Even though there is no cure for MS, currently drugs are used to slow the progression or reduce the frequency of relapses

- The global market for MS therapeutics has been projected to exceed \$12.5 billion by 2015**
- US has been termed as a growing market for MS therapeutics with the highest demand**

*http://www.wikinvest.com/concept/Multiple_Sclerosis_%28MS%29_Drug_Market **http://www.prweb.com/releases/multiple_sclerosis_market/autoimmune_disease/pr web3832894.htm

VALUE/ADVANTAGES

- A simple, cost-effective process using easily available raw materials
- Yields a product with high degree of purity (without requiring additional steps of separation, purification etc.)
- Molecular weight can be tailored to be in the range of 8-19KDa (hence overcoming toxicity issues; m. wt of over 20 KDa are known to be toxic)- with excellent control over the m. wt distribution
- High purity levels almost no acid residues (less than 1%)

APPLICATIONS

- Copolymer-1 is used for treatment of MS
- Suggested application in the treatment of non-autoimmune neurodegenerative disorders such as glaucoma, acute CNS injuries, Alzheimer's disease*

*Kipnis, J. and Schwartz, M., Dual action of glatiramer acetate (Cop-1) in the treatment of CNS autoimmune and neurodegenerative disorders, TRENDS in Molecular Medicine , Vol.8, 2002, Pg. 319-323

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners for licensing
- Patent applications filed: PCT #-<u>IN2009/000320</u>, Indian #- 0599/DEL/2008



Biomaterials from Regenerated Silk Fibroin

EXECUTIVE SUMMARY

Various novel methods for producing 3D porous biomaterials from regenerated silk fibroin (RSF) – which has wide ranging applications in tissue engineering, wound healing bandages, drug delivery, cosmetic applications etc.

TECHNOLOGY DESCRIPTION

NCL scientists have developed various processes for producing 3D porous biomaterials from regenerated silk fibroin (RSF). Our process for the accelerated gelation of RSF- resulting in a porous structure lowers the gelation time to a few hours instead of several days. The protein concentration can be between 0.1- 40%. It works in a broad pH range of 5 – 7.5, within temperatures ranging from 20-70°C. Another process using electrospinning of RSF from an aqueous solution, forms 3D porous structures (like non-woven mats) which have various biomedical applications. Surface modification of such biomaterials for improved performance is currently under progress.

MARKET POTENTIAL

- The market for biomaterials such as RSF was predicted to be of \$37.6 billion for 2011 and projected to reach \$64.7 billion by 2015*^
- The global market potential for tissue engineering and regenerative medicines has been expected to exceed \$118 billion by year 2013- mainly in the target potential areas of wound care and orthopaedics.**

VALUE/ADVANTAGES

- Free of microbial growth (superior performance of implants, lower toxicity)
- Shorter gelation time opens-up the potential spectrum of applications of the materials developed using this method
- Process is cheaper and faster (aqueous solution used instead of organic solventeliminates several intermediate steps)
- Implant that could be reproduced with great consistency and quality
- Wide range of pore sizes: 1-10 microns

APPLICATIONS

- In tissue engineering- as bio-degradable bioabsorbable scaffolds (due to lower inflammatory and superior mechanical properties) and damaged tissue regeneration (For ex. bone, nerves, ligament, etc)
- In wound healing bandages (provides a moist environment to facilitate re-epithiliazation, re-modeling of connective tissues and collagenization)
- As controlled drug delivery vehicles
- Silk fibroin peptides are used in cosmetics due to their glossy, flexible, elastic coating power, easy spreading and adhesion

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners for licensing
- Patent application filed: PCT filed-PCT/IN2010/000506



^{*} http://www.the-infoshop.com/report/mama179926-global-biomaterial.html - viewed 16/05/11 ^ http://www.the-infoshop.com/report/inde180852-glob-biomaterial.html-viewed 16/05/11 **http://www.medicalnewstoday.com/releases/141341.php- viewed 18/05/11

A library of new small molecules that could be used as anticancer, antiviral drugs

EXECUTIVE SUMMARY

A synthetic routine that allows one to manipulate the substrate flexibility at the final/penultimate steps- yielding a small library of modified nucleosides without the need for synthesising every compound from the beginning, and hence significantly reducing drug development time and costs.

BACKGROUND

Nucleosides are compounds containing a purine or pyrimidine base linked to a sugar. A recent modification strategy involves spiroannulation of sugar backbone in nucleosides and having access to collections of distinctive small molecules (analogues) by modifying the sugar backbone, is important for identifying new therapeutic candidates for various viral diseases and cancer. Current schemes follow "one scheme one nucleoside" approach – which is very limiting as each modification has to done separately.

TECHNOLOGY DESCRIPTION

NCL's technology provides a strategy that allows synthesizing spironucleosides with enormous flexibility to modulate the substituents and properties of the resulting compounds at the final/penultimate steps. The provision to manipulate the substrate flexibility allows this approach to yield a small library of modified nucleosides without synthesizing every compound from the beginning.

MARKET POTENTIAL

- There are large R&D efforts underway worldwide to identify suitable anti-cancer and ant-viral drugs/agents
- The global cancer therapeutics market is relying heavily of new drug development and is expected to reach \$60.6 billion in 2011*
- The antiviral drug market for 2008 was valued to have been at \$20 billion**

* http://www.frost.com; **www.leaddiscovery.co.uk

VALUE/ADVANTAGES

- Cycloaddition process used is of high synthetic efficiency
- These libraries significantly reduce drug development time and efforts
- Good yield in the presence of the recommended catalysts
- Easy and flexible penultimate bicycloannulation step involved

APPLICATIONS

- Drug discovery
- Developing therapeutics for various diseases, genetic disorders and infections
- Anti viral and anti cancer agents
- Chemical genetics
- Identifying new drug candidates

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- Ready to be licensed
- Patent application filed: Indian #-3103/DEL/2010
- Ramana, C.V. et al. (2011), Tetrahedron Letters, Vol 52 (1), Pg 38-41 (<u>link</u>)



A New method to synthesize anti malarial drug and its analogues

EXECUTIVE SUMMARY

A simple and efficient procedure for the chemical synthesis of otherwise naturally derived compound called flinderole and its analogues, which can be used to prepare drugs against multiply resistant strains of the malarial parasite, *plasmodium falciparum*. The process will enable the user to produce the compounds in commercial quantities.

BACKGROUND

Plasmodium Falciparum, the parasitic micro organism that causes the most clinically severe type of malaria is becoming increasingly multidrug resistant. New drug molecules are urgently required to be developed against such plasmodium strains.

TECHNOLOGY DESCRIPTION

Recently it has been discovered that naturally derived compounds called flinderoles show impressive anti-malarial activity. NCL scientists have developed a novel method for synthesizing flinderole analogues using a fully synthetic route (total synthesis) which has an overall yield of 17.2%. The process developed will enable to produce these anti-malarial compounds in commercial quantities.

MARKET POTENTIAL

- In 2008, there were 247 million cases of malaria and nearly one million deaths*
- Over \$1.8 billion was spent in 2010 to control malaria**
- There is a pressing need to develop new malarial drugs as the in many countries it has been identified that *P. Falciparum* is resistant to conventional malaria drugs like chloroquine, sulfadoxine-pyrimethamine and amodiaquine***

* http://www.who.int/mediacentre/factsheets/fs094/en/, ** World Malaria Report, 2010, World Health Organization, *** WHO briefing on Malaria Treatment Guidelines and artemisinin monotherapies Geneva, 2006

VALUE/ADVANTAGES

- Potentially could be used to treat drug resistant strains of *Plasmodium falciparum*
- A simple and efficient process
- The process developed results in high yields (17%) of flinderole analogues
- The process is useful for the production of commercial quantities of these compounds

APPLICATIONS

- Developing anti malarial drugs
- Agriculture

TECHNOLOGY STATUS/LINKS

- Demonstrated at the lab scale
- On the lookout for potential partners for spinoff and licensing
- Patent applcation filed: Indian #-0336/DEL/2011
- Dethe, D. et al. (2011) Biomimetic Total Syntheses of Flinderoles B and C, J. Am. Chem., 133, 2864-2867 (<u>link</u>)



Nanoparticle-polymer complex for sustained release of oral care products

EXECUTIVE SUMMARY

A process for preparation of nanoparticlepolymer multilayer complexes for sustained release of active oral agents, which can anchor and retain on the surface enamel of the teeth, for extended periods of activity.

BACKGROUND

Conventional layer-by-layer preparation scheme for preparing such nanoparticle-polymer multilayer complexes requires excessive use of polyanions and polycations with cumbersome separation process involved.

TECHNOLOGY DESCRIPTION

NCL scientists have developed a process for constructing nanoparticle-polymer complex for sustained release of active agents for oral care (for applications in toothpastes and oral rinses). Polymer multilayers are built up layer by layer on nanoparticles of 5-50 nm, consisting of a water repelling (hydrophobic) shell around a core of multiply (polyanion and polycation) charged material (the core can be of inorganics as silica, titania and/or clay) and encompassing outer layer with an affinity to the tooth enamel.

MARKET POTENTIAL

- The Indian market for oral care products grew to Rs. 3241crores at a growth rate of14.7% in 2009¹ and the market for US is headed to reach \$8.9 billion by 2012³
- There is a high market demand for novel, value added oral care products that will drive the market^{1,2}

- The global toothpaste market is expected to reach \$12.7 billion by 2012⁴
- The increase of sales is mainly seen due to growing awareness of hygiene and product innovation that provides additional features such as whitening and odor-fighting apart from just prevention of tooth decay

1. http://www.livemint.com/2009/05/06234303/HUL-losing-market-share-as-riv.html, 2. http://www.reuters.com/article/2011/05/11/idUS29974+11-May-2011+BW20110511, 3. http://www.packagedfacts.com/Oral-Care-Products-1190801/ http://www.prweb.com/releases/toothpaste_regular/whitening_tartar_control/prweb1 537104.htm

VALUE/ADVANTAGES

- Precisely controlled polymer multilayers can be built on nanoparticles without the requirement of the cumbersome separation step after each coating of the polymer layers
- Active compounds localised as per the requirement by fine tuning the outer layer of the complexes- retained in the complex despite extensive rinsing with water
- Enables designing systems that can anchor and retain on the surface enamel of the teeth for extended periods by adjusting the ionic strengths

APPLICATIONS

• Oral hygiene application- sustained release of antimicrobial/ flavour compounds

TECHNOLOGY STATUS

- Demonstrated at the lab scale/ proof-ofconcept
- On the lookout for potential partners for spinoff and licensing
- Patent application filed: Indian #-0696/DEL/2007



Self standing nanoparticle networks/scaffolds with applications in drug delivery, tissue engineering, catalysis etc.

EXECUTIVE SUMMARY

A novel process of preparing self standing nano particle networks with adjustable mesh size, prepared from various materials and having a wide variety of applications. The pore size ranges from nano to micro porous (500nm to 1mm) and is very precisely controllable

BACKGROUND

In nanoparticle scaffolds, no existing process can cross link the nanoparticles such that the porous scaffolds made are self standing and the process is easy to implement. The scaffolds hence derived have a wide range of applications.

TECHNOLOGY DESCRIPTION

A novel process of preparing self standing, crosslinked networks (scaffolds) of nanoparticles from commonly available materials as metallic, inorganic, semi conducting and magnetic particles, organic and polymeric compounds. The scaffolds have controllable mesh size and pore size can range from nano to micro porous. The particle volume fraction is between 0.5 to 50%

MARKET POTENTIAL

- The market for nanomaterials in the US alone was estimated to be around \$1.4 billion in 2008¹
- The demand for nanomaterials is projected to grow at an impressive 21% per year till 2013² indicating a significant market potential
- The global market for drug delivery has been projected to exceed \$57 billion by 2012³

1,2 http://www.freedoniagroup.com/ 3 www.biomedtrends.com/GetDetails.asp?CatName=Bio%20Lab

VALUE/ADVANTAGES

- Generic production procedure
- Can be formed in to ordered, structured phase, lamellar, spongy, cubic- preferably hexagonal network
- Has a precisely controllable directionality and pore size can range from 500 nm to 1 mm

APPLICATIONS

- Drug delivery- Inorganic/organic delivery scaffolds for Nitric Oxide- an important bioregulatory agent
- Tissue engineering- Cell seeding scaffolds
- Proposed applications of scaffolds
- Cell growth substrate
- Materials for solar cells
- Electrical/thermal insulators
- Catalysis- Catalyst support for small sizes available for diffusion of reactant molecules
- Metamaterials*- Electromagnetic devicesideally gold nano particles
- Electronic devices
- Chromatography

TECHNOLOGY STATUS/LINKS

- Demonstrated at the lab scale
- On the lookout for potential partners for licensing
- Patent application filed: WO #-WO2010070679, Indian #- 2828/DEL/2008
- Kamendra, P. et *al.* (2011) Self-Standing Three-Dimensional Networks of Nanoparticles With Controllable Morphology by Dynamic Templating of Surfactant Hexagonal Domains, *Chem. Mater.*, 23 (6), 1448–1455 (<u>link</u>)



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Nanogold-loaded sharp-edged carbon bullets as gene carriers

EXECUTIVE SUMMARY

A process for making sharp edged carbon bullets, embedded with nanogold particles for gene delivery applications - with a capacity to carry more DNA cargo and perform efficient transformation when compared to conventional gene delivery methods

BACKGROUND

With increasing research being directed towards genetic manipulation, the requirement for the ideal gene delivery vehicle is becoming vital. Carriers that can overcome current limitations of viral (toxicity, limited cargo capacity, quality control etc.) and other nonviral vectors (used mostly in animal cells) are required. There are very few options in gene carriers for plant cells.

TECHNOLOGY DESCRIPTION

NCL scientists have developed a process for the preparation of carbon embedded nano gold particles with sharp edges which can be used as gene carriers. The bullets are sharp enough to penetrate hard material, with less damage (a comparatively lower force of 0.1-0.2 nN required for penetration) and can be delivered with a convenient delivery gun .Intracellular gold particles (biogenic) synthesized by a fungus in situ, embedded on a carbonaceous matrix.

MARKET POTENTIAL

• The market for gene therapy (a major field for gene delivery applications) is expected to face a growth to \$5.7 billion in 2011¹

1http://www.outsourcing-pharma.com/Preclinical-Research/Gene-therapy-market-suffers-growth-setbacks

VALUE/ADVANTAGES

- Preparation process is very simple and easy to implement
- The carbon matrix forms 95% of the carrier reducing the amount of gold needed and the plasmid used per transformation
- Advantages of usage of gold particles- High DNA packing density, better transformation efficiency, low nuclease degradation, being in nano scale, higher surface area is obtainedmore gene cargo handled
- Advantages of usage of carbon support- Inert and less damage causing- wound caused due to penetration healed faster, better piercing capacity, for example, can effectively pierce hard plant cell walls, less force required to penetrate the plasma membrane as compared to silver nano needles

APPLICATIONS

- Gene therapy/ improved gene delivery for research and other applications
- Potential applications
- DNA based immunization, to study gene function and its regulation, to establish various disease models, metal ion removal, fuel cells, anti bacterial applications, catalysis

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- Ready to be licensed
- Patent application filed: PCT # IN2010/000513
- Prasad, B.L.V. et al. (2010) Nanogold-Loaded Sharp-Edged Carbon Bullets as Plant-Gene Carriers, *Advanced Functional Materials*, 20, 2416-2423 (<u>link</u>)



Injectable biodegradable gels with hydrophobic pockets/cavity for delivery of drugs

EXECUTIVE SUMMARY

Injectable, biodegradable, polymer hydrogel (that cross links in-situ) with one or more hydrophobic cavities which can be used to deliver drugs, with the desired release profile having various biomedical applications

BACKGROUND

Hydrogels are 3-D polymer networks with an unique ability to hold water, maintaining semisolid state giving them physical characteristics similar to soft tissues. They need to be easily administrable as preformed hydrogels and exist as flowable aqueous solutions before injection and immediately turn in to standing gels upon administration

TECHNOLOGY DESCRIPTION

The hydrogel developed by NCL scientists can be *in situ* crosslinked (which makes it suitable for injectable systems), with one or more hydrophobic pocket(s) which can be used to deliver desired drugs with desired release profile (gelation time- 1 to 30 minutes; degradation time- 1- 30 days; storage modulus from 5-110 Kpas). It comprises of a polymer backbone, a hydrophobic pocket (moiety being triclosan) and a water soluble cross linker (paclitaxel solubilized in alpha tocopherol)

MARKET POTENTIAL

 The US market for advanced drug delivery has been projected to exceed \$76 billion by 2014 not many organizations exist which can fulfill the task of making such specialized delivery techniques on a large scale¹ Also significant market potential in wound care exists²
 ¹http://www.pharmameddevice.com,²http://www.tissuegenesis.com/TGI%20Market %200pportunity%20Brochure.pdf

VALUE/ADVANTAGES

- Overcome the barrier of surgical implantation
- Does not require solvents as other biodegradable polymers might require which are harmful to the human body/some drugs may become inactive on coming in contact with the solvent
- In drug delivery applications, drugs can be loaded in the hydrophobic pockets present in the gels
- Provides precise control over the chain length, sequence and 3D arrangement of the polymer networks in the gels - hence prevents side reactions caused which may influence their performance

APPLICATIONS

- In site specific drug delivery systems/depots (Many important drugs are hydrophobic in nature and need to be administered in a solubilized form for the expected therapeutic effect- using our gel system, which has hydrophobic pockets to hold these drugs, the drugs can be delivered directly)
- Biomedicine- cell growing depots for tissue regeneration & protective membranes for the treatment of wounds
- Tissue engineering- space filling agents, delivery vehicles for bioactive molecules & tissue formation directing scaffolds

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- Ready to be licensed
- Patent application filed: PCT #-IB2010/003190



Continuous flow synthesis of sulphoxide compounds for use in drug formulations

EXECUTIVE SUMMARY

A process for continuous flow synthesis of pharmaceutically important sulphoxide compounds (used as Proton Pump Inhibitorsanti hypertensive drugs) with very less reaction time and easy scalability

BACKGROUND

Sulphoxide compounds such as prazoles and modafinils are currently produced using batch synthesis procedure which has longer processing times (1-4 hours). A more efficient process is required at industrial levels.

TECHNOLOGY DESCRIPTION

NCL scientists have developed a process of continuous flow synthesis of sulphoxide compounds with reaction times of ≤ 1 minute. The reaction results in over 90% conversion and over 95% selectivity towards the target sulphoxide compounds (with less than 5% formation of undesired sulphone compounds)

MARKET POTENTIAL

- GI disorders have been projected to affect more than a 250 million people in the 7 large pharma markets by 2012¹
- Overall GI tract disorders treatment market is expected to reach \$32.2 billion by 2014²
- In 2009, proton pump inhibitors were the third largest therapeutic class amounting up to \$13.6 billion of sales in the US³

¹www.astrazenecaannualreports.com/documents/2010/therapy_review_area_facts heets/gastrointestinal.pdf
² www.prnewswire.com/news-releases/reportlinker-adds-gastrointestinalpharmaceuticals-technologies-and-markets-68849697.html
³www.imshealth.com

VALUE/ADVANTAGES

- Process capable of easy scale up
- Results in high yield of the product with 95% of selectivity towards the sulphoxide compounds
- Conversion rate is > 90%
- The process provides an alternative solvent (to chloroform, which is a volatile solvent that evaporates at room temperature and changes the reaction mass)

APPLICATIONS

- The process can be used to make prazolesused to make drugs to treat the acid-related diseases of the gastrointestinal (GI) tract
- The process can also be used to make drug molecules that can be used as modafinil compounds used as central nervous system stimulants- wakefulness promoting agents
- In production of drugs which act as neuroprotective agents

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners for licensing
- Patent application filed: Indian #-1392/DEL/2009 & PCT



Process for the continuous flow synthesis of ß-amino crotonate (for use in anti-hypertensive drugs)

EXECUTIVE SUMMARY

A process for continuous flow synthesis of >99.98% pure ß- amino crotonates which are intermediates to calcium channel blockers (antihypertensive drugs)

BACKGROUND

ß-amino crotonates are generally produced by a batch synthesis procedure resulting in longer reaction times.

TECHNOLOGY DESCRIPTION

A novel production process for ß-amino crotonate using a continuous mode reactor, with reduced reaction time, yet resulting in higher yield (>93%) and high-purity end-product (>99.98%). The process can be catalytic or catalysis- free : used to produce ß-amino crotonate and its analogues.

MARKET POTENTIAL

- In Asia, an estimated 200 million people suffer from hypertension¹
- Calcium channel blockers help to decrease the heart rate, which can further lower the blood pressure, relieve the chest pain and control an irregular beat²-hence their use as anti-hypertensive drugs
- The world market for anti-hypertensive drugs is targeted to exceed \$66.2 billion by the year 2015³

¹http://www.investis.com/re, ²http://www.srspharma.com/calcium-channelblockers.htm,³http://www.prweb.com/releases/anti_hypertensive_drugs/blood_pr essure_medicines/prweb3453394.htm

VALUE/ADVANTAGES

- Catalytic as well as catalysis-free, continuous process
- ß amino crotonate yielded is of high purityprocess provides better control on product profile
- Reduced reaction time
- Can be prepared from a variety of amines and beta keto esters

APPLICATIONS

- As intermediates in the synthesis of Ca channel blockers such as amlodipine, nisoladipine, benidipine, nicardipine, etc
- Ca channel blockers are used as intermediates in preparation of anti-hypertensive drugs

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners for spinoff and licensing
- Patent application filed: Indian-1025/DEL/2011

Publication: Joshi, R. A. et al (2012) Continuous flow synthesis of β -amino α , β -unsaturated esters in aqueous medium, Green Process Synth 1, 205-210



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Low energy consuming novel impeller for stirred tank reactors

EXECUTIVE SUMMARY

A novel impeller that completely covers the stirred tank reactor causing uniform mixing with less power consumption

BACKGROUND

Stirred Tank Reactors (STRs) use mechanical stirrers with impellers to mix and distribute heat/materials – and are used in the chemical, pharmaceutical and fermentation industries. The efficiency of the STRs entirely depends on the design and location of the impellers in the tank. It is difficult to achieve uniform spatial distribution of energy in the STRs due to inability of the conventional impellers to reach the bottom of the tank and not achieve uniform temperature while operating at a low speed to avoid high shear zones in the fluid.

TECHNOLOGY DESCRIPTION

The impeller developed by NCL scientists is designed to cover the STR, offer low shear and provide uniform mixing, with relatively less energy consumption. This unique design also helps generate necessary flow even in the regions close to the tank floor. The impeller design achieves all this; yet occupies very little volume.

MARKET POTENTIAL

• The worldwide market for chemical mixers is estimated to be between USD 1-1.5 billion* in 2010 – which presents a good potential for impellers to be adapted in the chemical mixer market

* Data for year 2000 was obtained from this source: http://www.pcimag.com/Articles/Web_Exclusives/BNP_GUID_9-5-2006_A_10000000000001097398; A growth rate of 5% was assumed for the time period 2000-2010 to arrive at this market size

VALUE/ADVANTAGES

- Aids in reducing non-uniformities/ develop a uniform randomness throughout the tank
- Power number of our impeller is relatively low (more efficient) as compared to other standard impellers due to the uniform structure that helps maintain similarity in the flow, making energy distribution uniform
- Wake formation is almost zero behind the blades, reducing the drag and hence the power consumption
- Results in low shear rate, necessary for the shear sensitive media

APPLICATIONS

STRs are used in various areas of chemistry, pharma and fermentation at different scales of operation, mainly for:

- Mixing/blending two miscible liquids (of different viscosities), generating dispersions for gas-liquid and liquid-liquid reactions
- Keeping the solid particles in contact with the liquid to increase the solid-fluid interactions to achieve solid dissolution
- Crystallization

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners for spinoff / licensing
- Patent application filed- US & IN

Publication: Kulkarni, A. A. et al. (2011), Ind. Eng. Chem. Res., 50 (12), pp 7667–7676



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A single-step process for the preparation of highly pure alkyl esters used in making lactic acid, poly lactic acid

EXECUTIVE SUMMARY

A single-step process for preparation of highly pure alkyl esters, which is used in the manufacture of lactic acid and further to poly lactic acid – both with wide industrial and commercial applications

BACKGROUND

Highly pure alkyl esters, especially methyl lactate, have a very important and wide range of applications at an industrial level. The products formed in conventional processes are impure with residues of sodium sulphate and are corrosive; separation processes are expensive and energy intensive. In most of the processes, alkali metal is wasted in its sulfate form- cannot be recycled

TECHNOLOGY DESCRIPTION

NCL's process uses alkali metal carboxylate salts to convert to its respective pure alkyl esters by a single, direct esterification step. Alkali metal salts used are prepared from natural sources. This process results in alkyl esters of very high purity (99.5-99.8%). The use of mineral acid is eliminated in this process – hence, no undesired sulfate side products are generated. The resulting methyl lactate can be hydrolyzed to get pure lactic acid.

MARKET POTENTIAL

- The global market for polylactic acid (PLA) has been projected to grow from \$1.2 billion in 2010 to \$3.8 billion in 2016 at a CAGR of 18.7%¹
- PLA, being a biodegradable plastic, is increasingly being used in eco-friendly packaging – hence providing growth potential; The US biodegradable plastic

market is estimated to be around 350 million pounds and is expected to grow 15.5% annually, with PLA and polyesters as the fastest growing market segment²

• Lactic acid consumption, on the other hand, will continue to increase at about 7% PA from 2008 to 2013, at a global level³

1http://www.sunherald.com/2011/10/03/3479449/marketsandmarkets-global-lactic.html#izz1ZmfNhqo6(viewed04/10/11), 2html (viewed03/10/11)http://www.freedoniagroup.com/Biodegradable-Plastic.html (viewed03/10/11), 3http://www.bistemat.com/Plastic-Technical-Article asg7lterature100-1694&Paper=global-lactic_acid-PLA-market-pie-chart-worldconsumption-lactic-acid-polyethylene-terephthalate (viewed03/10/11)

VALUE/ADVANTAGES

- The products are of extremely high purity
- Pollution free process (by avoiding sulfate side-products)
- The byproducts (the corresponding carbonate salts) and the un-reacted carbon dioxide and alcohol can be recycled and reused in the process again –hence reducing cost

APPLICATIONS

- Methyl lactate is used in pharmaceuticals
- Lactic acid (derived from methyl lactate) is widely used in food industry and other applications
- Lactic acid is also used to produce poly lactic acid which is a biocompatible and biodegradable polymer (hence with applications in packaging, biomedicine, etc.)

TECHNOLOGY STATUS

- Demonstrated at the lab scale; On the lookout for potential partners for spin-off/licensing
- Patent applications filed: Indian #-1842/DEL/2009, PCT #- <u>IB2010/002203</u>

Publication: Barve, PP et al. (2011)Preparation of Pure Methyl Esters from Corresponding Alkali Metal Salts of Carboxylic Acids Using Carbon Dioxide and Methanol, *Ind. Eng. Chem. Res.*, 51 (4), pp 1498–1505



Slow release hydrogel system for nutrient delivery to recombinant cell lines

EXECUTIVE SUMMARY

Slow release polymer hydrogel system to feed nutrients to cell lines for optimal selection of high protein yielding recombinant cell lines

BACKGROUND

Recombinant proteins have wide ranging applications like biotechnology, medicine, research, drug development etc. The production of recombinant protein requires constant nutrient feeding to the selected mammalian cell lines. Identifying high yielding clones through the batch mode (which is traditionally done) can skew the results and lead to sub-optimal selection of the highest yielding cell lines, hence increases the chances of failure at large scale production stage. To overcome this, a process of slow nutrient feeding is required- that mimics the fed batch mode in shake flasks (most industrial production processes use fed-batch mode)

TECHNOLOGY DESCRIPTION

Polymer hydrogel mentioned can be used for slow/extended release (ranging over a period of 2-3 days to about 2 weeks) of nutrients to desired levels that can mimic fed batch conditions and hence used to identify more reliable clones and reducing the chance of failure at large-scale culture stage. These hydrogels could be used to release various nutrients like glucose, peptides, amino acids, nucleotides, etc.

MARKET POTENTIAL

 In 2008, the global market for biologics and biotechnology drugs was estimated to be over \$125 billion*

- The recombinant therapeutic protein market was projected to mature to \$53 billion in 2010^
- Any method that could increase the success rate of biotech-based drug discovery process has a huge market among biotech and pharma companies and R&D organizations.

**http://knol.google.com/k/global-biotechnology-market-review-world-top-tenbiotech-drugs-2008# -viewed 06/06/11, ^http://www.datamonitor.com/Products/Free/Report/DMHC1975/010DMHC1975.pdf -viewed 06/06/11

VALUE/ADVANTAGES

- Nutrients of differing molecular weights (even lower) can be administered with controlled/slow/continuous release profiles
- A short 2 step formation procedure
- Non- cytotoxic; does not affect cell growth
- Sterilizable by gamma irradiation
- Usage leads to more reliable clone identification and less chance of failure at large scale culture stage

APPLICATIONS

- Nutrient delivery, especially small molecules (in solid and liquid forms) for production of recombinant proteins in conditions that could mimic fed-batch mode. For ex., glucose, peptides, amino acids, nucleotides, vitamins, protein hydrolysate
- Cell culture- where controlled/slow release of nutrients is required

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners for spinoff and licensing

Publication: Gadgil, M. et *al* (2012) Controlled release of nutrients to mammalian cells cultured in shake flasks, *Biotechnology Progress*, Vol 20, Iss 1, Pg 188-195



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A novel process for making monomer used in producing Polybenzimidazole (PBI)-a specialty/engineering polymer

EXECUTIVE SUMMARY

A process for production of high yielding, very pure 3,3',4,4'- Tetraamino biphenyl (TAB) monomers, which are used for preparing polybenzimidazole (PBI) polymers.

BACKGROUND

TAB monomer is a valuable intermediate and end product in various areas. The current methods of production fall short in either achieving high yields or have impurities (presence of copper or its salts) in the end product. Also, some raw materials used are known carcinogens. Some processes also require high temperature and pressure-hence increasing the cost of production.

TECHNOLOGY DESCRIPTION

NCL scientists have developed a novel process for the preparation of highly pure TAB monomer, having large yields. The raw materials used are non-carcinogenic, unlike what the conventional methods use (e.g., benzidine). The reactions can be carried out at milder temperature (<100 °C) and pressure (250 psig). New, efficient and renewable catalysts for this process have also been developed. TAB monomer produced by this method does not contain any copper contaminants and no by-products are formed.

MARKET POTENTIAL

 Global specialty fibers market is expected to increase in size to over \$9.2 billion in 2012; out of which the market share of PBI fibers will be about \$111 million in 2012 (increasing at a CAGR of 12.3% from \$62 million in 2007)* • Furthermore, global fuel cells (where PBI membranes are used extensively) market is expected to grow from \$650 million in 2011 to \$1.6 billion in the year 2016.**

*http://www.redorbit.com/news/technology/1170230/bcc_research_report_states_global_mark et_for_specialty_fibers_worth/index.html (viewed 12/11/11), **http://www.marketsandmarkets.com/Market-Reports/fuel-cell-market-348.html (viewed 23/01/12)

VALUE/ADVANTAGES

- The purity of TAB is greater than 98%
- The raw materials used in this process are non-carcinogenic and cheap
- Copper and its salts are not formed along with TAB, making TAB obtained highly pure
- The reaction conditions are less harsh as compared to the currently available processes (lower temperatures and pressures – hence lower production costs)

APPLICATIONS

- TAB is used as a monomer in the production of PBI polymers, which are known for their excellent mechanical and thermal stability – and are widely used in engineering and flame-retardant applications
- PBI membranes are used in fuel cells
- TAB is also used as an anti oxidant and as an agent for stabilizing epoxy resins

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners licensing
- Patents filed/granted: US # <u>6979749 B2</u>, US # <u>6835854 B2</u>, US # <u>2009/0131678 A1</u>



Process yielding high value fuel additives (octane enhancers) from lignin

EXECUTIVE SUMMARY

Efficient process for the depolymerization of lignin to produce substituted phenolic monomer compounds that are further converted to fuel additives

BACKGROUND

Fuel additives like octance enhancers have been traditionally derived from non-renewable petroleum products. Renewable sources such as lignin are being explored as a source for producing fuel additives. A number of single step processes for depolymerization of lignin have been explored to date only with limited success. Existing two-step processes occur under harsher conditions (max reaction temperature can reach 420 - 900° C).

TECHNOLOGY DESCRIPTION

NCL scientists have developed an efficient 2 step process for depolymerization of lignin to substituted phenolic monomer compounds which could be further processed for use as high value fuels/additives. The process operates under milder reaction conditions (temperature range of 215- 250°C). The reaction time is of 5 mins to 2 hrs. Product yield is >25%.

MARKET POTENTIAL

• US market for specialty fuel additives including octane enhancers has been predicted to grow 2.2 percent annually to reach \$1.2 billion in 2012.*

* http://www.reportlinker.com/p0100129-summary/US-Specialty-Fuel-Additives-Market.html (cited- 21/05/2012),

VALUE/ADVANTAGES

- Yields fuel additives from a renewable source
- Milder reactions due to the solid acid catalyst used- work under 270° C
- Process is more environmentally friendly than the conventional processes due to the recyclable catalysts
- This process results in very little loss of the products in the form of gas or due to degradation

APPLICATIONS

• End products of the reaction can be used to produce high value fuel additives like octane enhancers

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners for spinoff and licensing
- Patents filed: IN# <u>2889DEL2010</u>



Single step process for making high-value chemicals like xylose and arabinose from hemicellulose

EXECUTIVE SUMMARY

Improved single step hydrolytic process for generating high value chemicals such as xylose and arabinose from hemicellulose

BACKGROUND

Xylose is a high value material and is used to derive xylitol which has wide range of applications – as an artificial sweetener, oral care products, food additives etc. Conventional processes to produce xylose from hemicellulose are highly corrosive and non-environmentally friendly due to use of mineral acid catalysts and the pH at which enzymes involved work. They are also expensive due to high energy input required and the erosion faced by the reactor material due to the super acidic nature of the reactions.

TECHNOLOGY DESCRIPTION

NCL scientists have developed a one pot, single step hydrolytic process for conversion of hemicellulose to xylose and arabinose. The process operates under milder reaction conditions (pressure range of 1-70 bar and reactor temperature of 50-250°C).

MARKET POTENTIAL

- The market size for xylitol in 2007 was around USD 300-600 million and is expected to grow by > 50% globally (as more people become health conscious)*,**
- EU accounts for 50% of world's production of xylitol, followed by Asia (30%) and then the US (20%) **

*http://www.hs.fi/english/article/Xylitol+is+gone+but+the+memory+lingers+on/113523 0733013 (cited-01/06/2012), **http://www.koreatimes.co.kr/www/news/special/2009/07/129_9089.html (cited-01/06/2012)

VALUE/ADVANTAGES

- Raw material (hemicellulose) used is cheap, easily available, and is derived from non-edible sources
- The product-catalyst separation can be done by simple filtration (heterogenous solid acid catalyst used is insoluble in the reaction medium, whereas the products are soluble)
- The process is anti corrosive and environment friendly since water is the reaction medium and process operates at a neutral pH
- Cost effective due to the reaction being noncorrosive in nature and hence industrially applicable

APPLICATIONS

• Generation of xylose, arabinose, glucose, furaldehyde, oligomers, etc. which can be further processed to produce value added chemicals such as xylitol, arabinitol, etc.

TECHNOLOGY STATUS

- Demonstrated at the lab scale
- On the lookout for potential partners for spinoff and licensing
- Patents filed: IN# 2889DEL2010, WO/<u>2011/092711</u>



Modified Porous Polymers with Enhanced Biocompatibility for Implants and Tissue Engineering Applications

EXECUTIVE SUMMARY

Surface modified porous polyethylene biomaterial which promotes cell growth and prevents microbial infections for applications in biomedical implants and tissue engineering.

BACKGROUND

Porous polyethylene (pPE) biomaterials are widely used for making biomedical implants. The pores in these implants facilitate growth of cells and blood vessels. Enhancing cell growth can significantly increase compatibility of the implant and reduce its rejection by the body. Implant rejection can also occur due to development of infection. Recent studies have reported high infection rates in marketed pPE implants requiring revision surgeries¹. Adding an anti-infective feature to these implants can help in solving this issue.

¹Common nose implant has high infection rate: study.

TECHNOLOGY DESCRIPTION

A novel surface modification process developed by NCL scientists resulted in a pPE biomaterial that promotes cell growth in implants and increases its compatibility in the body. This novel material provides sustained antimicrobial action which helps in reducing the risk of infection development. This material can also function as a reservoir and can be used in making implants with drug eluting features.

MARKET POTENTIAL

• The Indian market for pPE biomaterial products is estimated at Rs. 40-50 lakhs per year*.

• The world bio-implants market is estimated to be \$94.1 billion in 2012. This market is expected to grow at 7.3% CAGR# in the next 5 years.

*Internal estimate. #<u>Marketandmarkets.com Report, September 2012</u>.

VALUE/ADVANTAGES

- This novel biomaterial promotes cell growth.
- Biomedical implants made from this material have increased compatibility in the body.
- Anti-microbial action of this biomaterial reduces risk of infection and implant rejection.
- This material functions as a reservoir and can be used for making drug eluting implants.

APPLICATIONS

- Biomedical implants for non-load bearing applications namely craniofacial, ophthalmic, nasal, auricular and dental reconstructions.
- Implants for volume filling applications such as orbital reconstruction, i.e. repairing lower eyelid retraction, fracture of eye socket etc.
- Drug eluting implants.
- Skin grafting and scaffold applications in tissue engineering.

TECHNOLOGY STATUS

- Demonstrated at the lab scale.
- On the lookout for potential partners for spinoff and licensing.
- Patent application filed in India 535/DEL/2010; PCT <u>IN2011/000158</u>; Favorable patentability report (IPRP) received.



New Chemical Entities (NCE) for treatment of malaria and CNS disorders

EXECUTIVE SUMMARY

New Chemical Entities (NCE) that may be employed as potential leads to prepare antimalarial drugs or treatment of Central Nervous System (CNS) disorders.

BACKGROUND

Plasmodium falciparum strains are growing increasingly resistant to current line of drugs owing to their highly adaptive nature. Alternative drugs with novel structures and varying mechanisms of action are constantly needed to treat the disease. Alkaloid compounds are an important class of drugs with proven anti-malarial activity. Novel alkaloid based substituted molecules are being explored as potential anti-malarial drugs. Some of these compounds have also shown effective inhibition of a known target for CNS disorders.

TECHNOLOGY DESCRIPTION

NCL scientists have discovered NCEs (substituted pyridine based alkaloids) and an efficient, fully synthetic route for their synthesis. The NCEs have antimalarial activity and some analogues could be used to treat CNS disorders. The process has an overall yield of >65%. The reaction temperature is mild (~50 $^{\circ}$ C).

MARKET POTENTIAL

- In 2008, there were 247 million cases of malaria and nearly one million deaths^{*}
- Over \$1.8 billion was spent in 2010 to control malaria^{**}
- The CNS drugs market is set to face an increase from \$78 billion in 2010 to nearly \$81.8 billion by 2015#

* http://www.who.int/mediacentre/factsheets/fs094/en/, ** World Malaria Report, 2010, World Health Organization, *http://www.bccresearch.com/market-research/pharmaceuticals/drugs-central-nervous-system-disorders-phm068a.html

VALUE/ADVANTAGES

- Potential drug candidates (with high antimalarial activity) for the treatment of *plasmodium* and potentially, CNS disorders
- Efficient synthetic approach, with milder reaction conditions
- Higher yields in the order of >65% for all the compounds

APPLICATIONS

- Treatment of malaria
- Potential treatment of various CNS disorders

TECHNOLOGY STATUS/LINKS

- Demonstrated at the lab scale
- On the lookout for potential partners for licensing
- Patent application filed: IN# 0356/DEL/2012; W02013117986 A1
- Lead molecules NCLite-M1 and its analogues; CAS# 1404195-28-3
- IUPAC Name: 4(3*H*)-Quinazolinone, 3-(3*H*-pyrrolo[2,3-*c*]quinolin-4-ylmethyl)
- Mhaske, S.B. et al. (2012) Pd-catalysed Imine Cyclization: Synthesis of Antimalarial Natural Products Aplidiopsamine A, Marinoquinoline A, and their potential hybrid NCLite-M1, Organic Letters, 14 (22) 5804-5807.
- Panarese, J. D. and Lindsley, C. W. (2012) Biomimetic Synthesis and Biological Evaluation of Aplidiopsamine A, Organic Letters, 14 (22), 5808–5810.



Novel silica based substrate (SBA-15) for efficient small molecules analysis in mass spectrometry

EXECUTIVE SUMMARY

Mesoporous silica (SBA-15) based substrate that enables efficient and selective analysis of small molecules from a complex mixture that contains both small and large molecules, using mass spectrometry.

BACKGROUND

Analysis of small molecules (less than 700 Da) such as metabolites, pesticides, food contaminants using mass spectrometry is a challenge. To achieve this, several sample preparation protocols and chromatography techniques are used – decreasing the throughput and efficiency. Although methods such as MALDI MS provide the throughput desired, they suffer from interference due to the organic matrix in the spectral range of interest. There is a need for alternative methods that provide a combination of "matrix-free" analysis, minimal sample preparation and high throughput platform.

TECHNOLOGY DESCRIPTION

NCL scientists have developed a platform which utilizes mesoporous silica (SBA-15) for use in laser desorption ionization mass spectrometry (LDI MS). This platform selectively excludes the detection of peptides, proteins and similar larger entities, allowing only the detection of small molecules quantitatively. This has been demonstrated on numerous classes of small molecules and from sample sources such as food, microbial cultures, biofluids from humans and synthetic molecules.

MARKET POTENTIAL

• The MS market is expected to grow at a CAGR of 7.83% over the period of 2011-2015.

• Increasingly, MS is being adapted for various applications in clinical diagnostics, mandatory testing requirements of various regulatory agencies** - indicating a robust growth potential for MS and related reagents and consumables market.

Ref1 Ref2 Ref3

VALUE/ADVANTAGES

- Selective detection of small molecules without any chromatographic separation from a complex sample source.
- Can be used for detection and quantitative analysis of multiple trace components.
- Negligible sample preparation required thus reducing analysis time and cost.
- This method can be adapted for high throughput analysis workflows.
- Additional features could be incorporated by manipulating the substrate chemistry opening up new applications.
- Uses easily available raw materials leading to viable process scalability

APPLICATIONS

- Pharmaceutical quality control
- Food & beverage testing (for contaminants and pesticide residues)
- Diagnostics, forensics, narcotics, environmental analysis
- Biotechnology R&D

TECHNOLOGY STATUS

- Demonstrated at the lab scale for various sample classes
- On the lookout for potential partners for spinoff and licensing
- PCT application filed: WO2012111028 A3

