KIDNEY-INSPIRED MEMBRANES WITH SUPERIOR ANTIFOULING PROPERTIES

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Key Words: Membranes, antifouling, polymer brush, surface modification.

Membranes are a versatile separation technology, used in a multitude of industrial settings. They pose several inherent advantages, such as easy scale up and separation with no requirement for additives. This has caused increasing popularity in water purification and bio-separations. However, the major challenge of this technology is fouling, leading to a declining flux, which requires frequent, extensive cleaning to correct. Fouling is influenced by factors on different scales; macroscopically, the characteristics of the feed and the hydrodynamics of the membrane module will influence fouling. Interactions between foulants and the membrane surface, however, also affect fouling and are governed by fundamental physical forces, such as electrostatic interactions. Thus, all scales must be considered when designing membranes that are less prone to fouling.

To solve this problem, we can turn to nature, which provides us with a treasure trove of clever solutions to a wide range of engineering problems, such as those experienced in membrane processes. The kidney, for instance, is a remarkable organ capable of producing over four million liters of effectively protein-free urine over a lifetime with no significant fouling (1). The glomerulus is a bundle of specialized blood vessels, which carries out the first stage of kidney filtration, the stage most comparable to membrane separations. Within the lumen of these blood vessels, a brush-like structure is present, composed of proteoglycans and glycoproteins, which are responsible for the overall negative charge and hydrophilicity of this layer. The glomerulus also has notable macroscopic properties that can create hydrodynamic regimes that promote the back transport of adsorbed foulants. The combination of the brush structure and the resulting hydrodynamics of the system are believed to be key causes behind the superior anti-fouling properties of the kidney.

To translate this inspiration into membrane processes, the design that has been employed in this work is the grafting of polyelectrolyte polymer brushes as an antifouling layer onto commercial membranes. This grafting is achieved through surface-initiated controlled radical polymerization (SI-CRP) using ARGET ATRP (Activators Regenerated by Electron Transfer Atomic Transfer Radical Polymerization). The stimuli-responsive polymer brushes reduce fouling through steric and electrostatic repulsion, due to the negative charge of the layer in solvents. This has been demonstrated, thus far, in the filtration of silica nanoparticles and albumin as model foulants in water purification and bio-separations. In both cases, the flux decline over a fixed time for the polymer brush modified membranes showed significant improvement over the commercial membrane with maximum reductions in flux decline of 43% and 42% in the filtration of albumin and silica nanoparticles, respectively.

The combination of other macroscopic influences, together with further optimization of the polymer brush antifouling layer, has the potential to leverage the superior antifouling properties of the kidney to synthesize a class of next-generation membranes.

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SYNTHESIS AND CATALYTIC PROPERTIES OF HIERARCHICALLY STRUCTURED ZEOLITE CATALYSTS WITH INTRACRYSTALLINE MACROPORES

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Key Words: Hierarchical materials, heterogeneous catalysis, zeolites, macropores, porous materials

Zeolites belong to the most important heterogeneous catalysts. They are widely applied in crude oil refining, petrochemistry, fine chemistry, as well as in environmental applications. A unique feature of zeolites is their well-ordered micropore system with pore diameters similar to the dimensions of molecules. These small pores give rise to the shape selective properties of zeolite catalysts. However, the diffusion of molecules to and from the active sites confined within the micropores is very slow, which often leads to diffusion limitations. These diffusion limitations result in reduced utilization of the zeolite crystal and can also lead to reduced selectivity or lifetime of zeolite catalysts. A nature-inspired approach to overcome such diffusion restrictions is the utilization of catalysts with an optimally designed, hierarchical structure. In nature, mass transport systems, such as trees or lungs, possess an optimized hierarchical architecture to reduce transport limitations across a wide range of length scales.¹ Adapting this approach to zeolites can be realized by including at least one additional system of larger pores interconnected to the zeolitic micropores. Hereby, hierarchical zeolites coul already demonstrate enhanced diffusion properties and, consequently, better catalytic performance.³

In order to prepare a truly nature inspired catalyst, a guided material design is crucial. Therefore, the transport pore system must exhibit an optimal porosity and the zeolitic domains in between the transport pores need to be small enough to eliminate local diffusion limitations. The pore size can be neglected, if it is larger than a certain minimum pore size, usually in the range of macropores or very large mesopores.³ However, preparation approaches for hierarchical zeolites are often unguided and result mostly in materials containing relative small mesopores. In this contribution we introduce a synthesis approach for zeolite single crystals with intracrystalline macropores by a so-called inverse crystallization, which allows control over the porosity, pore size and wall thickness of the hierarchical zeolite (see Figure 1 b). This synthesis approach utilizes mesopores system—assisted crystallization. Furthermore, we show the effect of these additional intracrystalline macropores on the catalytic performance for the direct conversion of methanol to short chain olefins (MTO), with focus on coke formation and catalyst lifetime.



Figure 1 – a) Diffusion coefficient over pore diameter and b) schematic representation of the inverse crystallization

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THE EFFECTS OF EXTERNAL SURFACE BARRIERS ON DIFFUSION AND REACTION IN ZEOLITE CATALYSTS

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Key Words: Hierarchical Zeolites, Diffusion, Catalysis

Zeolites are attractive heterogeneous catalysts due to their crystalline structure, high surface area and thermal stability. However, conventional zeolites display diffusion limitations in many relevant catalytic processes. The slow diffusion rate through the extended network of micropores leads to low catalyst utilization and can, furthermore, lead to reduced selectivity and catalyst lifetime [1]. One nature-inspired approach to decrease diffusion limitations is to use hierarchically structured porous materials with an optimized network of broad and narrow pores. Observations in nature can help to provide a mechanistic basis to design the optimal pore network, since the architecture of nature is dominated by hierarchical structures. Hierarchical transport networks are indeed common in many natural systems, such as the respiratory and circulatory systems, as well as in leaves. At large length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow, while at smaller length scales transport is dominated by convective flow.

Nevertheless, recent experimental and computational work suggests that external surface barriers in zeolitebased, hierarchical catalysts might play a significant role in affecting overall transport and reaction rates in such catalysts [4]. Rao et al. [5] demonstrated the existence and impact of surface barriers on the alkylation of benzene with ethylene by comparing reactor simulations with experimental results.

In recent work in our group, ZSM-5 zeolites with similar bulk properties were prepared with different external surface properties, using different synthesis methods and conditions. The synthesized materials were studied extensively using different characterization techniques to determine their chemical, structural and textural properties. This set of catalysts was then used for appropriate catalytic experiments to investigate the impact of surface barriers on the catalytic properties of zeolites. This knowledge will be important to understand how surface barriers can be either avoided or exploited.

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TRADE-OFFS IN COMPUTER-AIDED BIOMIMETICS

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Key Words: Computer-Aided Biomimetics, Information Extraction, problem-solving

Biomimetics, the application of mechanisms observed in nature to inform technical solutions, is inherently crossdisciplinary. For the most part, however, practitioners are only expert in one domain, e.g., engineering. Being a layman in the other domain, biology, can make it hard and time-consuming to find and understand relevant information. Computer-Aided Biomimetics (CAB) involves the development of computational tools to overcome this domain-expertise mismatch.

Finding a bridge between engineering and biology has been challenging. Although a plethora of methodological approaches have been proposed to bridge the engineering and biology domains, Biomimetics remains adventitious and research intensive. We give an overview of previous research efforts in CAB and motivate our approach that revolves around the resolution of biological trade-offs. This is a unique approach, as previous work has always aimed to extract engineering functions from biological texts. We describe our novel CAB system that extracts trade-offs, a within-domain concept to indicate a dialectical relation between two or more biological traits.

We provide a description of our dataset for the extraction of trade-offs from biology research papers, as well as our state-of-the-art Relation Extraction system. The dataset consists of over 1.5k sentences taken from biology research papers, describing a trade-off or similar high-level relation between two or more concepts. Furthermore, we provide an in-depth analysis of the information extracted by our CAB system from a corpus of 10k biology research papers. We show in a qualitative analysis that our system extracts key concepts and relations from biology research papers that are relevant to Biomimetics.

Unique to our approach is that our system makes it feasible to collect a comprehensive list of the system parameters and solution principles used in biology. This enables statistical analysis, such as finding the distribution of fundamental principles among the resolution of various trade-offs. Notably, the solutions to trade-offs differ little over various hierarchical levels of biology. This makes our finding relevant to any research that aims to find desired, but underutilized, properties observed in nature.

AN EVOLUTIONARY APPROACH TO KINETIC MODELLING INSPIRED BY LAMARCKIAN INHERITANCE

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Key Words: process-model mismatch, diagnosis, information, Lagrange multipliers.

The mechanistic description of kinetic phenomena requires the construction of systems of differential and algebraic equations where a high number of parameters and state variables may be involved. The complexity associated with kinetic phenomena frequently leads to the construction of kinetic models characterised by some degree of approximation. Whenever an approximated model is falsified by observations, its mathematical structure should be evolved embracing the available experimental evidence [1]. Nonetheless, improving a model is a time and resource intensive task that heavily relies on the presence of experienced researchers. An evolutionary approach to kinetic modelling is proposed in this work which is inspired by the theory of evolution proposed by Jean-Baptiste Lamarck, namely the theory of Lamarckian inheritance [2]. The approach is illustrated qualitatively in the sketch in Figure 1. Lamarck states that the evolution of living beings is directly driven by their interaction with the environment. The use/disuse of an organ



Figure 1 – Analogy between the evolution of a giraffe and the evolution of a kinetic model in a Lamarckian framework.

determines the evolution of that organ towards higher/lower complexity. The long neck of the giraffe is frequently reported as an example to explain Lamarck's theory. Primitive giraffes with a short neck would strive to reach the highest leaves. This behaviour, driven by necessities of adaptation, would lead to an elongation of the neck during the giraffe's lifetime and the characteristic of the long neck is inherited by the offspring. Lamarck's theory is now widely dismissed. Nonetheless, the field of epigenetics stemmed directly from Lamarck's philosophy and aims at explaining the complex mechanisms behind the hereditability of environment-driven phenotype changes [3]. In this work, the principles of Lamarckian inheritance are translated into a framework for kinetic model building. In the proposed framework, the evolution of model structures is data-driven. When the model is overfitting, model parameters that are irrelevant for representing the data are removed from the model structure. When the model is under-fitting, relevant model parameters are evolved into more complex state-dependent expressions. A statistical index, namely a Model Modification Index (MMI), based on the Lagrange multipliers statistic [4], is proposed as a measure of model misspecification to support the evolution of approximated kinetic models towards higher levels of complexity. The use of the MMI is demonstrated in a simulated case study to diagnose misspecification in an approximated kinetic model of baker's yeast growth [5].

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DEVELOPMENT OF BIOMIMETIC SURFACES WITH AN ANTIBACTERIAL EFFECT BASED ON THE STRUCTURE OF DRAGONFLY WINGS

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Key Words: dragonfly, nano-pillars, biomimetic surfaces, replication, antibacterial effect

Antibiotics, in the past so effective against wide spectra of infections, are nowadays omnipresent and their widespread availability, misuse and gradual accumulation over time in the environment is the main reason behind the sudden increase of bacterial resistance. However, it has been shown that some natural surfaces (e.g., cicada wing) possess topography which renders their surface antibacterial and resistant to bacterial colonization without any active chemical substance. The mode of action is such, that adhered bacterium is exposed to shear stress between the cell wall and surface topography (e.g., an array of nanopillars) resulting in cell deformation, wall rupture, lysis, and death. Moreover, the mechanical nature of bacteria-surface interaction virtually eliminates the risk of the sudden emergence of bacterial resistance since the whole process depends solely on surface topography and mechanical properties of the bacterial cell.

In this work, we propose to examine topographies of Czech domestic insects (e.g. dragonflies, damselflies, moths), test their antibacterial properties against model Gram-positive and Gram-negative bacteria and replicate their topology using suitable techniques allowing the transfer of antibacterial topology into a larger scale. We believe that such materials have the potential to be the answer to increasing number of MDR bacteria and secondary infections.

MICROFLUIDIC CHEMOTAXIS SCREENING PLATFORM FOR QUANTIFICATION OF BACTERIAL VIABILITY

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Key Words: Anti-microbial Resistance, Chemotaxis, Fick's Law, Microfluidics

It is estimated that by 2050, over 10 million people globally will die each year as a direct result of antimicrobial resistance. This global health crisis has arisen from the use and often misuse of antibacterial drugs and poses a serious threat to all aspects of modern healthcare. The discovery of new antibacterial agents is, therefore, imperative. In this regard, novel surfaces with light activated antimicrobial agents and antimicrobial paints for use in healthcare environments are being developed and need rapid evaluation. To this end, we aim to utilise the natural phenomenon of bacterial chemotaxis (the ability of bacteria to move towards or away from environmental signals by flagella-mediated motility) to perform live-dead analysis on bacterial cells after exposure to antibacterial agents in a microfluidic device. One of the challenges of this approach is to quantify chemotactic motility independent of convective-diffusive forces, to distinguish between alive and dead cells. Operational parameters (e.g. flow rates) must be carefully chosen in order to avoid masking the chemotactic separation by lateral movement of bacteria due to diffusion in the direction of the chemotactic gradient. In this work, chemotaxis defined by Fick's Law in a T-junction microfluidic chip was modelled by computational fluid dynamics (CFD), where chemotactic velocity was given as a function of the chemoattractant concentration and concentration gradient. The microchannels of the T-junction in the microfluidic device were 500 µm wide, 100 µm deep, and with a main channel length of 25 mm (Figure 1a). A range of flow rates was tested, and the spatial concentration of live bacteria estimated. The chip was fabricated by micro-milling channels on 1 mm thick polycarbonate. Pseudomonas aeruginosa PAO1 (mini-Tn7-GFP) was used as the model organism (in the midlog phase to ensure maximum motility), as it causes serious infections in immunocompromised people and is frequently multidrug resistant (MDR). A chemoattractant, L-Threonine (4mM in 10 mM HEPES buffer) was tested on live bacterial culture. Bacteria and L-Thr were injected into the chip at three flow rates: 0.1 µl/min, 1 µl/min and 5 µl/min (each inlet). Fluorescence images were taken at the T-junction and 10 mm downstream of the channel to quantify the bacterial distribution across the channel width.



Figure 2: (a) Schematic of the microfluidic T-junction device (width = 500 μ m, depth = 100 μ m, length of main channel = 25 mm. Graphs show the normalised bacterial concentration from fluorescence images at the T-junction (b) and 10 mm downstream (c) for 3 different flow rates: 0.1 μ /min (purple), 1 μ /min (black), and 5 μ /min (red) each inlet. The decrease in the fluorescence signal at the left edge of the channel (10 mm downstream) is indicative of chemotactic motility.

At 10 mm downstream, results indicated that bacteria moved ~75 μ m from the left-side channel wall at 1 and 5 μ l/min (Figure 1c). At 0.1 μ l/min flow rate, concentration of bacteria became homogenous due to diffusion, while at 5 μ l/min the chemotactic focusing was the most apparent, in agreement with the CFD model. CFD-assisted testing has hence proven to be an efficient way to determine suitable operational parameters. Work is being conducted to fabricate novel designs to create chemotactic gradients for efficient live-dead bacterial separation, leading to a rapid bacterial viability analysis.

A NATURE-INSPIRED PASSIVE AIRFLOW SYSTEM FOR CARBON CAPTURE AND SEQUESTRATION

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Key Words: Passive Airflow, Carbon Capture

Increasing levels of carbon dioxide (CO₂) emissions continue to threaten communities and biodiversity worldwide. Carbon capture and sequestration (CCS), where CO₂ is removed from the air and stored so it cannot return to the atmosphere, has the potential to reduce these impacts. However, CCS systems are unpopular due to their high energetic and financial costs [1]. To-date, few systems exist that can effectively remove CO₂ from ambient air and the majority are designed solely to remove CO₂ from flue gas produced by power plants. Although half of global emissions can be captured from flue gas, the other half, produced by sources such as transportation, can only be removed from ambient air through direct air capture (DAC) [2]. To address the issue of high energetic cost, and provide another option for ambient air CCS, a passive airflow system was developed. This system replaces the energetic input used to bring CO₂ into DAC systems from devices such as electric fans. Passive airflow is enabled with a design inspired by prairie dog burrows where a mound-shaped pipe connector forces air to move upwards through a column, due to wind flowing over it. Optimal capture of CO₂ is facilitated by the interaction of air flowing upwards, countercurrently with a chemical solution flowing downwards. This solution contains carbonic anhydrase enzymes which facilitate the conversion of CO₂ into carbonate ions which combine with magnesium ions in solution to form solid magnesium carbonate. This crystal precipitates out of solution, sequestering the CO₂ in a solid form. Scaled up, the current prototype could have a comparably low energy cost to other CCS technologies. However, passive airflow can be adapted for other carbon capture methods lowering the energy cost of CO₂ removal from air and potentially resulting in a lower financial cost making CCS a more attractive option for reducing the effects of climate change.

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A NATURE INSPIRED APPROACH TOWARD SUPERHYDROPHOBIC COTTON FABRIC FOR MULTIFUNCTIONAL USE

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Key Words: Superhydrophobic; Antibacterial; UV-resistant; Moisture control; Oil-water separation.

Nowadays, there is growing concern on the cotton fabric related to stain, dust, harmful UV irradiation, growing bacteria and other microorganism due to its hydrophilic nature. Inspired by nature, the high repellency of lotus leave, have gained the more attention due to its special wettability properties. These are the two key factors to create superhydrophobic surface; roughness and low surface energy materials¹. In this work, a one step process was used to artificial modify the surface from superhydrophlic to superhydrophobic. Here, the fluorinefree silane was used as a coating material. The contact angle of modified surface is more than 150° and tilt angle less than 10°. It can sustained the superhydrophobicity in saline water (3.5% w/v) with good washing, thermal and chemical stability. It showed the bacteria anti-adhesion activity against the E. coli bacteria with moisture control ability. It could be used for the oil-water separation about 99% efficiency. Thus, the applied functional coating can be used for household as well as in medical due to its multifunctional applications. This process was simple, eco-friendly, and economical. Cotton fabric consists of abundant hydroxyl group on its surface. Moreover, silane is found as a low surface energy material and contains both hydrophobic and hydrophilic groups. These hydrophilic groups react with the hydroxyl groups through the chemical bonding, and showed the washing durability. Due to inherent micro structure in the woven matrix, they are considered heterogeneous (air pockets at the interface) with different rough scale. Here, the low surface energy material was used to prepared the superhydrophobic surface without using any nanoparticles. The modified surface showed the excellent repellence towards the all liquids based products such as tea, milk etc. with blood. The pristine cotton can absorb the water quickly and create the humid environment and works as a nutrient for the bacteria grow. So, it has the good moisture control property and bacteria anti-adhesion properties due to its superhydrophobic nature. These are key points which inspired to create this unique coating to modify cotton fabric. Here, the fluorine-free silane was used as a low surface energy material which is economical and nontoxic in nature. This modify surface was prepared without using any harmful nanoparticles or adhesive. This functional coating did not alter any properties of fabric such as flexibility and color. So, it could be concluded that the modify fabric can be used in various fields without any harmful effect on surrounding as well as human skin.





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STRUCTURAL CHANGE OF FLUID CATALYTIC CRACKING CATALYSTS STUDY INCORPORATE WITH COKE CHARACTERIZATION FORMED IN HEAVY OIL VOLATILIZATION/DECOMPOSITION

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Key Words: FCC, Heavy oil, Volatilization/decomposition, X-ray computed tomography.

Porous structure change of catalyst and coke formation from feedstock on fluid catalytic cracking (FCC) catalyst have studied by a more comprehensive set of analyses, include 2D, 3D analyses incorporate with carbon/coke characterization teniques. Carbon/coke formed from a heavy oil volatilization/decomposition with different oil-to-FCC catalyst ratio (1:3, 1:2, 1:1, 2:1 and 3:1) to simulate the aging of FCC catalyst in a continuous oil refinery. Carbon/coke was formed for all used FCC catalyst samples that is generally increases with the increase of oil-to-FCC catalyst ratio. Coke formation has been correlated with the porosity change of the FCC catalyst, that more carbon/coke formed on the FCC catalyst due to the increment of oil-to-FCC catalyst ratio leads to the decrease of total pore volume and surface area. Zeolite is evenly distributed from the FCC catalyst particle centre to the exterior for all pristine and used FCC catalyst particles. The interior porous structure of single FCC catalyst particle is not affected by the coking. However, the exterior porous structure is completely disappear for all used FCC catalyst, that could cause by porous frame collapse and the coking clog the surface pores. The more comprehensive study of the structural change incorporate with the carbon/coke characterisation, which helps to understand the progressive degredation of FCC catalyst caused by porous structure change more in depth. Figure 1 is an example of 3 D tomogram and the radial distribution profiles of pristine FCC catalyst.



Figure 4 Resulting segmented tomogram of pristine FCC catalyst (left); Radial distribution profiles of clay, pore and zeolite elements, with respect to the particle centre, of a pristine FCC particle (right).

MUSSEL INSPIRED CHEMISTRY AND BACTERIALLY SYNTHESISED POLYMERS FOR ORAL MUCOSAL ADHESION AND DRUG DELIVERY

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Ulceration of the oral mucosa is common, can arise at any age and as a consequence of the pain can adversely affect speech and swallowing and ultimately lessen quality of life. The mainstay of therapy of such disorder remains topical corticosteroids but while they do manage the ulceration in most instances, they are not without problems. There is thus a need for a delivery system that (1) is easy to apply and wear (2) that is retained on the oral mucosa and (3) that allows delivery of different corticosteroids in a controlled manner. To date there remains no means of achieving local controlled delivery of corticosteroids to the oral mucosa.

Attaching membranes to wet surfaces, offers significant challenges in medicine. Therefore, most recent approaches in the field have concentrated on functionalising biomaterials with different biomolecule. Marine mussels utilise a simple chemistry to attach to a wide variety of wet surfaces, and the adhesive proteins they secrete contain both catechol and amine functional group. The mussel inspired polydopamine contains similar functional groups to those of adhesive proteins and thus allows us to replicate the adhesive functionality via a very simple dopamine based chemistry.

In this research we investigated the feasibility of using the dopamine self-polymerisation chemistry on a new family of naturally produced, bacterially synthesised polymers known as Polyhydroxyalkanoates (PHAs). Once synthesised and extracted from the bacteria to an appropriate purity, the PHAs were simply solvent-processed into films for subsequent surface functionalisation with polydopamine. Characterisation of these films were carried out via Fourier Transform Spectroscopy which confirmed dopamine functionalisation, surface energy measurements via contact angle and Scanning Electron Microscopy for surface morphology. Finally Alamar Blue Metabolic Activity confirmed biocompatibility of the coated polymer post cell seeding.

HO NH_2 HO

Figure.1 shows the dopamine molecule.

On the left hand side is the catechol group and on the right the amine group.

A STUDY OF SOLAR ENERGY STORAGE USING SUGAR MIXTURE

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Key Words: Solar collector, PCMs, sugar mixture

This study is focus on solar energy storage technology using all-glass evacuated tubular collector to collect energy from solar. The advantage of this technology is lower heat loss during time of collecting energy. The solar collector is installed at the facility in Bangkok Thailand. Five parameters which are temperature of water, solar radiation, air speed, ambient temperature and %RH on each day have been collected during experiment. The phase change materials (PCMs) are also installed for storing energy from the solar collector. The advantage of PCMs is good energy storage because it store energy as a latent heat. In this study, sugar mixtures are used as PCMs since it has high specific heat and high latent heat. The sugars studied are sucrose, fructose, glucose, and sugar alcohol are xylitol, and erythritol. The sugar mixtures study in melting temperature range of 80 to 100 degree Celsius. In this study, the eutectic temperature of two and three components are calculated and compared with the experiment to find the phase change material suitable for the temperature range of interest.

WHALE 'BLUBBER' AS BIO-INSPIRED PHASE CHANGE MATERIAL

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Key Words: Bio-inspired, 'Blubber, TES, PCM

In nature, all living things have various features to survive. For example, marine mammals have an adipose tissue system that protects them from harsh conditions in their environment. This tissue also known as "blubber" provides various features to marine mammals. Buoyancy, insulation, protection and energy storage are among the tasks of this tissue.

Thermal energy storage systems are regarded as key to sustainable use of renewables to meet increasing global energy demand. Phase Change Materials (PCM) with thermal energy storage properties are commonly used in a wide variety of applications based on melting-freezing principle. PCMs can be inorganic or organics. Fatty acids are examples of organic PCMs.

Biological systems have inspired development of many materials with improved thermal properties¹. In this study, inspired by the 'blubber' found in whales and its energy storage task, a fatty acid mixture as phase change material (PCM) for thermal energy storage was prepared. The aim is to prepare a mixture of fatty acids and oleyl alcohol to achieve a 'blubber' like phase change behavior with a melting range of about 35-37°C like in different whale species². PCMs with this phase change temperature can be used in the design of special garments for special conditions such as divers and climbers.



Figure 1 – Heating cooling curve of sample

The PCM sample is designed to have a composition of %55.7 Oleic acid, %20.8 Palmitic acid, %12.9 Stearic acid, %10.5 Myristic acid and %0.1 oleyl alcohol based on the composition of G. Macrorhynchus whale. Figure 1 shows the heatingcooling curve of this developed bio-inspired PCM. The phase change regions are encircled on this figure. The melting point of the sample is around 38°C and the freezing point is about 34°C. The melting point is near the melting point of the whale 'blubber', but the freezing point is lower, which indicates supercooling of the sample. The development of PCM with different binding materials and nucleating agent to avoid supercooling are ongoing. Thermal stability, cyling and storage capacity will be determined in future studies.

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