SPOMAN OPEN SCIENCE

PROJECT EXCERPT BROCHURE

This folder contains excerpts of some of the many active projects within SPOMAN open science.

Preface - Benefits of collaboration

Industrial companies are very limited to their end goals, and the basic research done at the universities can provide a more dynamic and free approach and the sharing of knowledge between the recipients is a catalyst for scientific progress as well as industrial progress. Every subject in SPOMAN open science could have a huge collaboration potential in both basic and applied science. As an example, take graphene, it is a material of interest and thus subject to relevant development and sharing of knowledge. A development of the science surrounding graphene will benefit the basic research institutes in a way such that the research done is shared between the two, thus creating a faster development into the capabilities of the material within the laboratories. One major barrier in the scientific world is the unwillingness to share information. This tendency might have slowed down scientific progress, both knowledge wise but also economically, when boosting the prices of patented technologies. What the companies get by sharing their knowledge is the possibility of potential breakthrough discoveries that was not necessarily on the scope of their own applied scientific development. The freedom of scientific progress within the universities has a higher potential of serendipity as they are more able to pursue curiosities and odd results than are the companies with specific end goals. The investment of the companies is minimal, but the knowledge shared from the universities directly to the companies is highly valuable. Also, students within open science gain experience within a specific field that the companies are dedicated within. These students working on projects that are directly in link with the mission of the companies without the companies have any drawback of this collaboration. A favourable interaction between the students and the companies is beneficial for the future work and the incorporation of new employees with already gained expertise before joining the companies. They are easily settled and fast incorporated. Potentially cutting of many months of wages within the companies due to training periods and imbedding them into the company.

Graphene Research

Introducing Graphene

A piece of graph**ite**, as found in your everyday pencils, adhesive tape and a decent amount of curiosity. That is the ingredients in the discovery of graph**ene**, and the following Nobel prize in 2010, one of todays most researched materials. Graphene a carbon material just as coal, diamond and graphite, but only a single atom thick is also the world's first discovered 2D material, and it comes with a vast range of properties that have a huge application potential. To make things even better, the raw material for obtaining graphene is graphite, as mentioned earlier, a cheap widely available material. A two-dimensional structure simply means that it only has two axes, a completely flat material. That property in itself is very interesting as it provides a very high surface area comparable to weight, which essentially means that a very minute amount of the material is sufficient for many purposes.

Value

The intrinsic properties of graphene include electric and thermal conduction, flexibility, strength and a modification capacity of adding chemical groups, known as functionalized graphene. These modifications can react with other desired materials to form interesting composite materials and materials with specific properties, that previously were physically and chemically impossible. These composite materials allow the properties of graphene to function on other materials that for example are already in use in the industry, but could be enhanced with graphene for additional capabilities. The electrical characteristic of graphene is the freely movable electrons that span the entirety of the structure. The structure itself is formed in a lattice of hexagons, much like a chicken net and is a fairly easy structure to understand. In spite of these valuable properties, in both basic and applied science, there is some scientific issues still to be overcome to take advantage of graphenes full potential. It is important to be able to generate an amount and purity that fits the application of interest. Of course, one could imagine that you do not have much to work with when you have a single layer of graphene, although very pure, on a piece of tape as it started out when it was discovered. This traditional method that led to the Nobel prize is known as mechanical exfoliation. Today liquid exfoliation using chemistry allows for graphene to be exfoliated and suspended in a liquid, thus a much higher amount of graphene will be available and much more rapidly.

Research in Graphene

Several students in collaboration with Open Science have put a lot of effort into the research on the electrochemistry of graphene and how to scale the production of graphene as well as how to apply graphene in composite materials, which is highly relevant research for many industrial purposes. Specific types of electrochemical methods on graphene allows for a lowering of the very stable hexagon structure such that a functionalisation is possible. The research provided a way to obtain a higher yield of graphene than previously and furthermore with a better purity and low number of defects, but still with a challenge of byproducts deposited on graphene due to the high voltage needed for this method. The students further explored the method of obtaining functionalized graphene and specifically functionalized graphene was used as a filler in plastic-graphene composites, and showed promising results in mechanical tests and ought to be investigated further. Also, functionalized graphene with the ability to be used in synthesis as an initiator component proved promising.

Application

These findings spark the ideas of graphene layered plastic materials with capability to conduct electricity, imagine adding a new dimension to plastic where you could build electrical circuits without the classical materials used today or have electrical components without wires at all. Clothing at the hospital that monitors heartrate, blood pressure, temperature and vital parameters as an electronic ink, that is both strong, flexible and easily stretched. Wires you can't see or feel. Potentially removing the use of telemetric apparatuses in healthcare. EMI shielding that are more effective and with more light transmittance than any of the compounds used for shielding today. Antistatic properties of multi-layered graphene (MLG) in PVC Composites (melt-mixing method) that would be valuable for companies that use material that comply to antistatic regulations for commercial application. Graphene also have the ability to function as super capacitators, which is much like a super battery with low charge times and infinite charges as well as much higher effectiveness, meaning longer charge drain. Membranes for many purposes for example water purification with potential to even drink seawater from a straw containing graphene technology, as graphene is highly impermeable and a strong candidate for membrane filtering.

Polymer Research

Introducing Polymers

In 1939 a synthetic polymer material for the first time became commercially available and it was a success beyond anything seen before. This polymer is something we have all seen, touched, worn, and know the name of. The brand name – Nylon. Produced and commercialised by DuPont, one of the largest and oldest companies in the world. The success of Nylon ought to have demonstrated a glimpse of the potential that lies within the study of polymers. Especially considering that Nylon was just the first synthesized of a potential of millions of different polymers. To the day, polymers both synthetic and biological are being researched to learn and harness their capabilities in order to overcome technological issues or to gain a general understanding of their chemical proprieties. Especially in the modern societies issue with plastic pollution, we need to understand the science of polymers to be able to break down the polymers for the plastics to enter circularity.

You can think of a polymer like pearls on a string, where each individual pearl is the units that build up the full polymer, with it coming the full variety of function depending on what the individual pearl contains. As such both DNA and proteins are part of the category of polymeric molecules.

Value

Organic chemistry and inorganic chemistry are often two very distinct fields of studies however, this is not to say that they cannot be intertwined, and this intertwining begins within the field of organic chemistry and more specifically polymers. Materials such as aluminium or lithium are often very limited to their own intrinsic capabilities. The problem is that typically researchers as well as the industry seek to exploit those capabilities in combination with another materials property, but this task is not easily managed. It would be beautiful to imagine that you wanted the strength of aluminium and the lightweight of lithium and if you made the alloy of these two metals you would get a lithium density material with the strength of aluminium. Of course not. However, your alloy reaches a compromise of the properties of the materials, and often that is sufficient for many purposes, but what if it is possible to exploit these traits even further. At this point we begin to intertwine the two fields of chemistry. Polymers can actually be grafted to the surface of a wide variety of materials such as metals, glass etc. Usually these materials are very unreactive, but by grafting polymers to them, their surface gains the chemical properties of the polymers and retains the property of the bulk material in its core. This is of significant scientific and industrial interest. Polymers are highly customizable and dynamic, the exact opposite of metal materials thus it is easily imaginable that all of a sudden, an aluminium surface might be able to have a whole variety of properties embarked by the attachment of the polymers.

Research in Polymer Brushes

Polymer brushes are just polymers that are densely packed on a surface. Like the hairs in a brush. The technique of applying polymers to a surface has been known for many years however it requires an air-free method using a metal catalyst, which have troubled the industry, as it hinders its applicational value. The aspect of bioaccumulation of metal and the struggle to remove the metal post reaction, inspired the research of a new method using an organic photocatalyst in combination with a readily available visible-light source. Removing the polluting component of metal catalysis. In Open Science several students and researchers have put effort into the optimization of this light driven process. Here they successfully formed polymer brushes of several different polymers. Issues such as density, crosslinking and grafting methods are all in consideration in order to refine the process and to ready the process for application. Furthermore, this process inspired the idea of light-initiated adhesives.

Polymer Brushes – Application

Structural materials submerged into saltwater at powerplants usually succumbs to the force of nature either by marine life or corrosion, here the addition of polymer brushes to these structures could prolong lifetime to such a point that it is economically beneficial, maybe you could imagine that it could prevent biofouling completely. Another application is seen in biomedical materials such as implants or metallic grafts in surgery. The idea of coating these materials in polymers may reduce the number of post-surgery infections as many bacteria are dependent on attaching to a surface.

Reversible Adhesives – Application

Electronic devices are often glued together in order to make the components stick to the template model. Here the components are often very hard to handle afterwards due to the fact that they cannot be effectively separated. Thus, it is extremely difficult to isolate the compounds and the material is no longer viable for reuse. Especially in windmills where the components have been very difficult to separate in expired wind turbine wings. The resin used in windmills is effectively a glue that binds all the materials together, but the resin cannot be reversed as soon as it has been applied. Here polymer brushes have a potential new field of real application. Polymer brushes could be applied as a trigger responsive adhesive as a coating on two separate components. Reversible adhesives could counter the way that we decompose wings and other composite materials that are glued together. Not just that, but also inside the components of electrical devices. Such as mobile phones and so on.

Research in RAFT Initiators

Atom transfer radical polymerization (ATRP) in some form, is the go-to method to produce polymer brushes on surfaces. However, it has a limit in which types of polymers it can utilize to synthesize on a surface. Another method called reversible addition fragmentation chain transfer (RAFT), is more versatile and can produce polymers from a broad family of monomers. That way RAFT is interesting when looking into forming new polymer brushes. The RAFT technique has also been developed in a light mediated form. Research have been conducted in order to investigate the possibility to perform light mediated RAFT polymerization in aqueous solutions. Here specific salts can be grafted to the surface in order to initiate the polymerization.

RAFT Initiators – Application

RAFT polymerization is effective in synthesizing a wide range of polymers in a way that is precise and uniform unlike ATRP. Additionally, the RAFT process allows the synthesis of polymers with a range of different architectures such as branches, stars and rings. This versatility and reliability are an advantage in the industry as quality control is essential. In any process that are to be transferred to industrial application the conditions in which the process takes place also have to be flexible and versatile. RAFT can be performed in many solvents including water. It is free of potential polluting metal catalysts.

Research in Self-immolative Polymers

Self-immolative polymers are a class of polymers that can undergo a depolymerization on demand. This basically means that they can deconstruct into monomeric units upon a single triggering event. After triggering the deconstruction of the polymeric unit, usually by cleaving a stable end cap, the whole molecule becomes unstable and this leads to spontaneous fragmentation of the polymer. The research within these types of polymers have a huge application potential as most of the polymers used in the industry today, do not have this versatility.

Self-immolative Polymers – Application

These types of polymers have a great potential in sensing devices, microcapsules and nanoscale assemblies such as micelles and other types of polymeric vesicles. The monomeric units released upon deconstruction could have reporter molecules such as fluorophores attached, which unquenches as they are fragmented into monomers, thus giving a signal. This could be exploited for medical application as a drug release reporting signal. In combination with targeting moieties, one could imagine the ability of vesicles to carry drugs to certain areas in the body before you trigger the disassembly of the vesicle. Especially in cancer treatment where you want to target specific areas of the body to minimize the damage to healthy areas. Another application could be the ability to incorporate self-immolative polymers into food packaging, thus being able to make plastics that could easily be degraded at a recycling facility by triggering the deconstruction.

Research in Plastic Recycling

Synthetic polymers are often synonymous to plastic, and today plastic has a pollution problem on the brink of plastic even being synonymous to pollution. Polymer research is often interlinked with the aspect of circularity and recyclability. The recycling process is often key in many newly synthesized polymers and it is thought into the design such that decomposition and breakage can be handled. Furthermore, the basic research within polymer chemistry is the fundamental basis of which researchers come to expand their knowledge on plastic, and knowledge is an absolute necessity when trying to understand and combat plastic pollution.

Plastic Recycling – Application

One of the biggest issues in plastic recycling is the lack of societal consensus. There is no specific method on how to handle materials for recycling. Even within the borders of our own country there is no consensus or procedure. How could this issue then be tackled on a global level?

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Visit us at **www.spoman-os.org** for more information.

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