

The Green Chemistry Grand Challenge:

A collaboration between the Universities of Illinois, Leeds, Manchester, Pennsylvania State, Southampton, Utrecht, Washington - Seattle, Wisconsin - Madison and York

Sustainable chemical manufacturing at a local level through international collaborative research

Summary

Waste biomass represents a sustainable and carbon-neutral source of valuable chemicals at a local level. This chemical potential can only be realised through the collaborative efforts of a multidisciplinary and multinational team of technical and socioeconomic experts. An integrated multi-theme research structure is proposed to achieve this aim, which will require transatlantic multi-agency funding.

Background

The products of the chemical industry are ubiquitous in modern society and have greatly improved our quality of life through applications such as healthcare, electronics, housing and food. The increasing world population and associated economic growth in developing countries will place increasing demands on the chemical industries. However, the inevitable decline in the availability of low cost fossil feedstocks and increasing public concerns over the environmental impact of manufacturing processes based on traditional resources demand the greater exploitation of alternative, renewable plant-based feedstocks, which are available at a local level. Products derived from biomass can also be considered to be carbon-neutral as well as environmentally friendly (the carbon released at end of life being equivalent to that captured by the plant growth) if the manufacturing processes used to achieve extraction and chemical modification are themselves environmentally acceptable and do not require energy demanding and polluting long-distance transport. Interest in, and commercialisation of, products from renewable resources is not well advanced¹, despite the above drivers and governmental and societal requirements for sustainable development. This presents a worldwide problem, which will continue to escalate in severity if this high profile and politically important area is not quickly and significantly advanced. The challenge of solving the international problem of meeting future demand and realising market potential of local manufacturing across the globe requires large-scale integrated research carried out with a multidisciplinary and multinational expertise base, the complexity of which is undoubtedly the reason why this area is fragmented and under developed.

The Collaboration

The Worldwide Universities Network has acted as a catalyst to enable a multidisciplinary group of internationally renowned researchers from Europe and the USA to come together under the theme of Green Chemistry to form a framework for the partnership required to achieve the

¹ *Currently only ca. 51MT of crop derived industrial materials are produced, with nearly half of this being fibres. The current market penetration is <1% for polymers and no more than 2% for lubricants and solvents, with only surfactants of the major classes of chemical products having high renewable resource usage (20%). The total market potential over the next 10-20 years has been estimated at typically ten times these values. (McKinsey has projected value creation stemming from new biotech applications in the chemical industry at \$160 billion by 2010).*

desired objectives of the proposal. This framework will be expanded upon to incorporate further essential expertise from other non-WUN universities to complete the partnership. Interest is well established within the existing framework, which is poised to begin a cohesive research effort aimed at investigating, developing and advancing the knowledge in this field in order to offer real solutions to this real problem. The complex and multidisciplinary nature of the proposal is reflected in the need for expertise in the areas of chemistry, engineering, agricultural science, transport, forestry, and environmental and socio-economic studies, belying the common misconception that Green Chemistry is purely about chemistry.

The Research

The overall proposal objective, or so-called Grand Challenge, is to prove the economic, environmental and social value of agricultural and forestry wastes for the manufacture of valuable chemical products at a local level. We will establish and apply throughout the research socio-economic and environmental assessment tools to ensure that we adhere to triple bottom line benefits (see Fig 1). Green Chemistry methods and technologies will be fully utilised in the science and technology research so as to minimise the environmental footprint of the whole process and help achieve close to carbon-neutrality and true sustainability. Targets will include the direct extraction of valuable chemical products and also mixtures, materials and platform chemicals for subsequent conversion to final products. By developing at-source, easy-to-use techniques we will add value to local rural communities, reduce the environmental footprint of current chemical manufacturing plants, spread employment from industrial to rural regions and reduce transport costs.

The requisite research will be carried out over a number of key scientific and technological themes, in parallel with socio-economic and environmental assessment and demonstration/application themes:

- Selective biotransformation of waste agricultural and forestry biomass to platform molecules (used as building blocks to make a wide range of chemicals);
- Selective extractions from biomass using green chemical techniques;
- Green chemical transformations of platform molecules to value added products;
- Novel uses for biomaterials including starch, cellulose, silica and chitin;
- Environmental impact, fate and toxicity studies on new products;
- The development of socio-economic and environmental assessment tools and their integration throughout the Grand Challenge projects;
- Demonstration of economic and technical feasibility of the technology platform.

We have estimated a total cost for the Grand Challenge of ca. £4.5 million over a five-year period.

A regular virtual seminar series aligned to these themes will be organised by the Network to support the research and to open the discussions to researchers not directly involved in associated projects. The existing WUN Global Exchange Programme (for students and staff) will continue to provide further support.

Figure 1: 3D Diamond Model for the Grand Challenge Project - Overall research framework set within economic, social and environmental axes

