Carbohydrate as Sustainable Materials for the Future

CarboMet

Relevance and problem

The advent of the European bioeconomy first presented in 2012 set out plans to transform the chemical industry in Europe to a more sustainable economy. One of the key underlying principles of the new bioeconomy framework was the utilization of waste resources, in particular food and agricultural waste. On average the EU produces 956 million tonnes of agricultural biomass per annum and a large constituent of this is carbohydrate. Exploitation of this waste is crucial in reducing the dependence on fossil-based products and creating a circular bioeconomy. The investment and funding made in the next 5-10 years will profoundly affect the European bioeconomy in the future. Harnessing waste biomass as a feedstock source will create new supply chains across the continent impacting both growth and development in EU member states.

Challenges and opportunities

Nature has provided an unlimited resource of carbohydrate-based materials and whilst the complexity and diversity of carbohydrates is challenging, this very diversity provides an opportunity to access new chemical and sequence space by tailoring the polysaccharide structure and functional properties for various applications. The inter-relationship between structure and function is perfectly highlighted when comparing cellulose and starch. Both are made of glucose residues but they play different roles in nature. Cellulose provides structural support to plants, whereas starch is primarily used as an energy source. This relationship is a prerequisite to developing a new generation of sustainable biomaterials that can address global challenges in packaging, healthcare, agriculture and personal hygiene. We envisage a future where digitization is integrated into the R&D workflow and manufacturing processes, with machine-based learning approaches being used to guide the design of new materials. This will be a powerful predictive tool for the European chemical industry and underpinning this are the CarboMet initiatives on developing robust and appropriate measurement and analytical tools, as well as new metrological procedures and ISO-standards. We identified 4 key industry areas where carbohydrate materials will play a crucial role, these are packaging, films and displays, healthcare and prosthetics, food and beverage and textiles. Key areas were highlighted as priority research to accelerate the development and commercialization of next-generation biomaterials.

- **Develop new processing capabilities for carbohydrate based polymers.**
- **Increase production capacity of biodegradable raw materials.**
- **Modification of natural biopolymers using enzymes.**
- **Development of machine learning and predictive algorithms to determine structure-function-property relationship.**
- **Industry - academic networks for collaboration.**

Biomaterials applications

Biodegradable films for food packaging are being produced from wood and forestry residues.[1] In addition cellulose nanofibers are being used in next-generation display systems.[2]

Carbohydrate polymers are being used in bio-inks. These are polymeric material housing viable cells and are being used in tissue regeneration.[3]

References

1. Futamura cellulose films division: http://www.futamuragroup.com/divisions/cellulose-films/products/cellophane/
2. LTG ULM GMBH, Bistable ChLCD displays press release: https://www.bmgmis.de/en/products/bistable-chlcd-displays/
3. Gao, B.; Yang, Q.; Zhao, X.; Ma, Y.; Xu, F. Trend Biotechnol. 2016, 34, 746-756.

Acknowledgements: CarboMet would like to thank Kompuestos and Futamura for the valuable feedback.

CarboMet is a four-year Collaborative Support Action ['CSA'] funded by the EC Horizon 2020 Future and Emerging Technologies initiative

E-mail: projectmanager@carbomet.eu
Website: carbomet.eu
Twitter: @CarboMet_EU