Synthetic carbohydrate polymers from xylose

The intensive use of polymers has brought challenges associated with their overwhelming reliance on fossil-fuel resources, limited end-of-life options and environmental persistence. We need to move away from our reliance on fossil-based polymers and towards a circular economy. Our vision of sustainable polymers involves creating materials derived from renewable feedstocks and with multiple closed-loop life cycles, such as mechanical and chemical recycling or biodegradation.

However, one major challenge is to obtain materials with adequate properties. Towards this goal, our team has been investigating the incorporation of monosaccharide units into synthetic polymer backbones. Our hypothesis is that because sugars are natural, abundant, non-toxic, biodegradable, biocompatible, and highly functionalisable, renewable materials with desirable attributes could be made. In particular, we have identified D-xylose as a promising precursor for the preparation of bio-derived and functionalised polymers, due to its abundance and low cost.

In this talk we will describe how various classes of xylose-based, oxygenated polymers (including ethers, esters, carbonates) can be made using polymerisation techniques such as acyclic metathesis polymerisation (ADMET) [1-2], thiol-ene polymerisation, and ring-opening (co)-polymerisation (ROP and ROCOP) [3-4]. Xylose-based monomers can be combined with other renewable feedstocks such as fatty acids derivatives, renewable cyclic anhydrides or CO_2, to produce polymers with up to 100% renewable content.

Throughout our studies, we have refined our understanding of the structure/properties relationship of those [3→5]-xylan hybrid polymers, changing the nature of the monosaccharide or comonomer used, replacing oxygen atoms for sulfur in the polymer backbone [5-6], exploiting the sugar's stereochemistry to tune crystallinity, and assessing the overall recyclability and degradability of the materials made.

The resulting sugar-based polymers form a promising material platform, and the first steps taken towards their commodity and specialty applications will be presented (e.g., polyethylene-like films, solid polymer electrolytes[7], hydrogels).

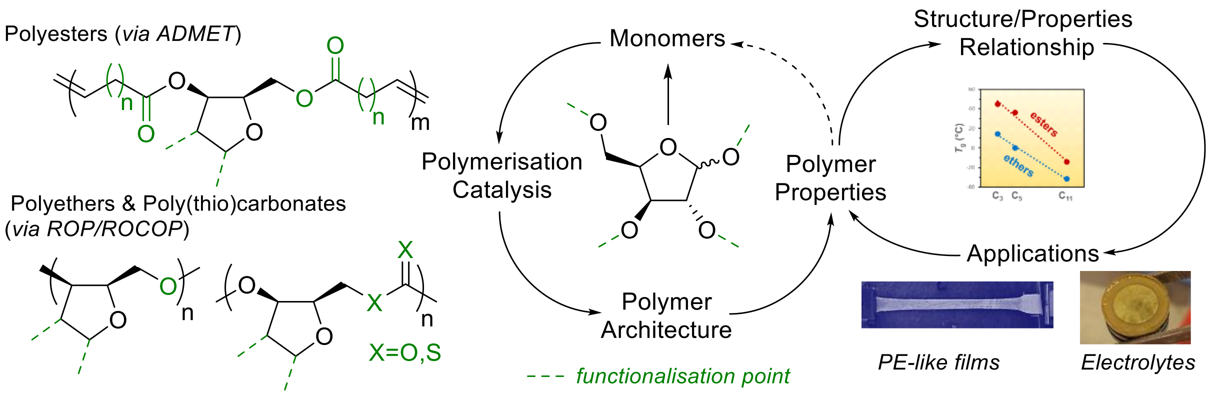

Fig. 1 Xylose-based polymer platform: selected examples of structures and applications.

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