TITLE OF RESEARCH TOPIC: Recycling of Polyurethane Waste

Summary:
The global market for polyurethanes (PU) is expected to increase to 30 million tons by 2029, which means we can expect an even greater amount of PU waste. In line with global efforts to reduce environmental pollution, there is a clear need to recycle PU waste.

Mechanical recycling and pyrolysis are unsuitable for treating PU waste due to the cross-linked structure in the case of PU foams and environmental issues. Therefore, chemical recycling of Pus has recently become an intensively researched topic. Current recycling technologies suffer from incomplete urethane group degradation and/or various side reactions, resulting in recycled polyols of low quality or highly complex degradation mixtures that are only suitable for use in less demanding applications.

The aim is to develop an energy-efficient PU degradation process that allows effective degradation of urethane groups with a low amount of aromatic amines generated as side products to produce high-quality polyether polyols suitable as a feedstock for the production of new PUs.

Research techniques used:
The degree of degradation of urethane and urea groups in PU structure will be evaluated by ^{1}H NMR. As complementary methods to determine the efficiency of PU degradation, we will use SEC/UV-MALS-RI, FTIR and MALDI-TOF MS. The distribution of end-group functionality of recycled polyols will be determined by HPLC, while two-dimensional liquid chromatography (2D-LC) will allow us to assess polyol functionality type distribution as a function of the polyol molecular weight. The hydroxyl, acid and amine numbers will be determined by titration, the Na+ and K+ content by inductively coupled plasma mass spectrometry (ICP-MS), the water content by Karl Fischer titration, while the appearance of the polyols will be assessed visually (color, transparency). The thermal stability of the recycled polyols will be determined by thermogravimetric analysis (TGA) and the glass transition temperature by differential scanning calorimeter (DSC). The purity of the isolated aromatic diamines (TDA, MDA) will be evaluated by NMR, GC-MS and HPLC. The structure of the PU from recycled polyols will be characterized by FTIR, NMR, while the mechanical properties of the PUs will be evaluated using a dynamic mechanical analyzer (DMA).

The reason why the topic is innovative:
Because PU waste need to be recycled, it is crucial to thoroughly understand the mechanisms of PU degradation and the exact chemical composition and molecular weight of the degradation products formed. This can contribute to in-depth understanding of PU degradation and thus to the development of more efficient methods for PU recycling, the synthesis of new PUs from the recycled feedstocks, and the development of new and innovative materials, which can be used in various industrial and commercial applications. Efficient chemical recycling of PUs can help to reduce the environmental impact of plastic waste, while the production of valuable chemicals from PU waste (polyols, isocyanates, diamines) can have a significant impact on the development of the chemical industry in terms of reducing its dependence on non-renewable fossil resources and improving the circular economy. Finally, chemical recycling of plastic waste can also have positive economic effects by creating new jobs in the recycling industry.

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The Scientists4Future Slovenia has received funding from Ministry of Higher Education, Science and Innovation. The project is co-executed by University of Ljubljana.

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