From gas to grease: Synthesis of sustainable poly(hydroxy-urea-urethane) greases via CO_2 chemistry and comprehensive property analysis

Weronika Milanowska

The project concerns the development of a new type of grease, in which the main thickener will be a polymer derived from carbon dioxide (CO_2). Although this may sound surprising, there are already many methods available for converting CO_2 into valuable raw materials that can be used in the synthesis of polymers or functional additives. This is especially important today, as we face the threat of an ecological disaster caused by global warming. For this reason, every technology that has the potential to utilize CO_2 emitted by humans is especially important.

The goal of the project is to create a safe and environmentally friendly grease, which is matching or exceeding the performance of modern greases. Here, the thickener is not, like in most cases, a metal-based soap (such as lithium), nor synthesized using toxic components. In general, greases resemble the structure of a sponge, as illustrated in Figure 1. The thickener forms a porous structure with channels that soak up the oil. During working conditions, this grease can release oil (a phenomenon called shear-thinning), ensuring proper lubrication of components.

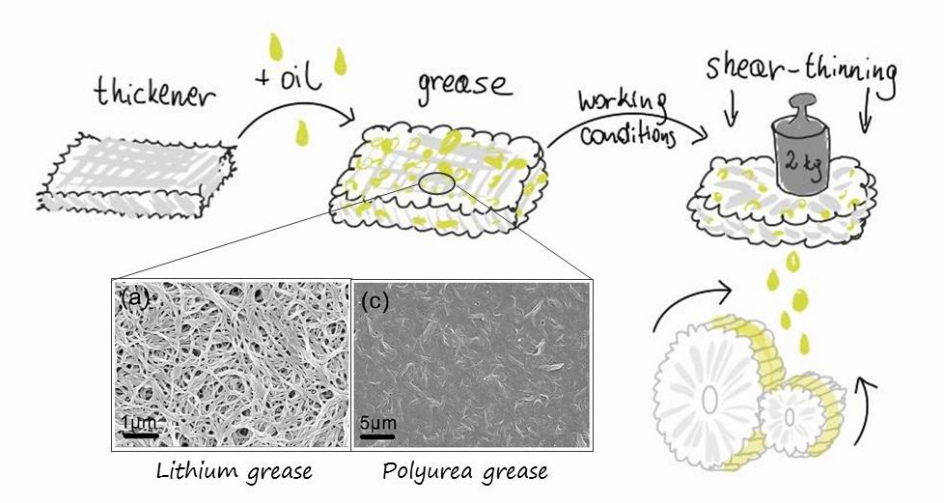

Figure 1: Grease working principle; SEM images of lithium- and polyurea-based greases.

Currently, the market is dominated by greases based on lithium - a raw material considered critical due to its simultaneous use in the developing electrical and electronics industries. Unfortunately, the possibilities of degradation of waste resulting from the use of such lubricants are limited and their release into the aquatic environment and/or soil is a significant problem. A better outlook is offered by greases with polymeric thickeners, such as polyurethane or polyurea, but their synthesis typically involves isocyanates, which are hazardous to health. The choice of base oil is also significant in grease formulation. Selecting among mineral, synthetic and natural oils allows the tuning of grease properties for specific operating conditions and later disposal.

In this project, CO_2 will be used in two stages of synthesis: the first one leads to the formation of polyureas (via polycondensation with diamines) and the second will yield bis(cyclic carbonates) by reacting CO_2 with diepoxides. Using both semi-products, poly(hydroxy-urea-urethanes) will be synthesized and tested as grease thickeners. The synthesized materials will be combined with oils to create lubricant compositions. They will be analyzed in terms of their structure, rheological properties and lubrication efficiency under operating conditions. They will also be compared with commercially available lubricants. The project also assumes the development of a simplified method of synthesizing lubricant directly in oil, which will significantly reduce the number of synthesis steps.

The project will provide breakthrough solutions for the lubricant and polymer chemistry industries and demonstrate how CO_2 can be used as an environmentally friendly building block for functional materials, supporting strategies in green chemistry and the circular economy.