Public summary of PhD-thesis of Dannie van Osch  
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Design and Applications of Hydrophobic DESs

It is a major problem that many environmentally harmful solvents are used in the chemical industry. For example, solvents that are used in the purification industry and for the removal of components in the oil-industry, such as the removal of sulfur from earth oil and mercury from natural gas. Nowadays approximately 28 metric tons of solvent is used in the industry. Most of these solvents are potentially toxic for the environment and the people that have to work with them. Moreover, they are potentially flammable. Thus, it is a necessity that solvents are investigated that are more sustainable and safe.

This thesis describes a new generation of water-immiscible solvents: ‘hydrophobic deep eutectic solvents’, also known as hydrophobic DESs (‘hydrophobic’ means ‘water-immiscible’ and a ‘eutectic’ is ‘the lowest melting point of such a mixture’). A DES is easy to prepare by mixing two solids components, which upon stirring form a liquid. The fact that they are composed of two solid components contributes to their sustainable character since solids have a lower volatility and so burn less easy. Another advantage is the fact that they can be produced from natural, non-synthetic components. Finally, it is a huge advantage that the component can be chosen for a specific application.

This new generation of water-immiscible solvents was discovered in 2015 at the Eindhoven University of Technology, which is presented in this thesis. The team of investigators has shown that they are applicable for the removal of volatile fatty acids, for example acetic acid, from water. The removal of components from water is a promising future application for this kind of solvents, since for some applications this is difficult and currently environmentally harmful. A second application that has been tested shows the potential of hydrophobic DESs for the removal of heavy metal ions from water. In the most ideal circumstances it was shown that more than 99% of heavy metal ions such as cobalt, nickel and magnesium could be removed from water, an impressive amount. It was also shown that it could be reused. This is the most important step for the implementation of these innovative solvents in the chemical industry as a successful replacement of conventional solvents.

The hydrophobic DESs were also used for the capture of CO2. The problem with solvents currently used for this applications in the industry is that they are expensive. The solvents presented in this thesis are comparable in efficiency and have comparable properties with alternative solvents under investigation for this application, but are cheaper and need not purification after preparation.

Despite that these applications already show that hydrophobic DESs have potential for academic and industrial use, sustainability is still a point of improvement and so an investigation was dedicated towards this. It was specifically searched for plant extracts that are known for their sustainability, solid components that are already implemented in industrial or commercial applications. Two examples are menthol and thymol, which can be extracted from the mint plant and thyme plant. The combination of criteria for their use and the choice of ‘green’ components ensures that the solvent is sustainable as a product and in its use.

A final principle that is shown in this thesis is the production of oil-in-water emulsions prepared with a hydrophobic DES. These environmentally friendly emulsions can be considered as small droplets of water-immiscible DES that is stabilized in water. It is now of interest to investigate these emulsions for specific applications. For example, if these emulsions can be used for the removal of low
concentrations of a contamination in the water phase, something that is still a challenging task. Another potential application is the development of environmentally friendly emulsions, for example, the preparation of cosmetics and pharmaceuticals.

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