BIO-DERIVED FEEDSTOCKS FOR NATURAL DEEP EUTECTIC SOLVENTS

Dalia Bražinskienė, Audrė Kalinauskaitė, and Svajus Joseph Asadauskas

Dept. of Chemical Engineering and Technologies, Center for Physical Sciences and Technology (FTMC), Vilnius, Lithuania

Deep eutectic solvents represent mixtures, where two or more compounds interact through hydrogen bonding (i.e. H-bonds) and dramatically reduce their melting point. As a result, even some solid substances can become liquid just by being mixed together without any chemical reaction, only by acting as H-bond donors or acceptors. Many metal salts or hydroxides can engage into such eutectic phenomena, driven not only by H-bond interactions, but also due to the processes between Lewis or Bronsted acids and bases. Although heating usually greatly accelerates the dissolution of solids and formation of deep eutectic solvents, thermodynamically ambient conditions might as well be sufficient for the liquids to form. Recently, researchers have shifted their focus to Natural Deep Eutectic Solvents (NADES), which are composed of organic compounds from bio-derived resources. Low melting points and unusual solvency of NADES is attracting a lot of interest from various industries, including food, cosmetics and plastics. Amino acids and sugars are among the most widely employed components, acting as H-bond acceptors and H-bond donors respectively and as a result these NADES are gradually becoming a significant player in bio-economy. Betaine and its salts have been studied with particular attention as H-bond acceptors by a number of teams. Nevertheless, fluidity and stability of betaine formulations in NADES remains quite uncertain. With a purpose to establish the relationships between fluidity or stability characteristics and the compositions of betaine-based NADES, a series of H-bond donors from bio-derived feedstocks were screened experimentally. The principal results demonstrate that the dissolution of solids strongly depends on the ratios between NADES components. In some formulations, the concentration interval is quite narrow for the blend to become liquid and retain fluidity. For example, NADES formulations of betaine and xylitol combine into sufficiently stable liquids only when betaine concentration is within 33% to 40% wt. Although clear uniform liquids might form after initial heating and retain their fluidity for many hours at room temperature, prolonged storage of some NADES often results in phase separation and formation of solids. These processes might be accelerated or inhibited, if some water is present in the formulations. Nevertheless, the tests show that betaine-based NADES can be produced as clear stable liquids with excellent low temperature stability by using a broad selection of various short chain sugars, polyhydric alcohols, dicarboxylic and functionalized acids or similar compounds as H-bond donors. These components can be obtained from diverse sources and not necessarily in a pure dehydrated form. It should be noted that purity is important for NADES fluidity and stability, so candidate formulations must be carefully screened for their suitability. In conclusion, despite remaining formulatory and technical challenges, employment of sugars, polyhydric alcohols and similar H-bond donors for betaine-based and other types of NADES promises high degree of innovation and a broad spectrum of possibilities for bio-derived material utilization.

Contact: S. J. Asadauskas, Dept. of Chemical Engineering and Technologies, FTMC, Sauletekio 3, 10257, Vilnius, Lithuania. Email: svajus.asadauskas@ftmc.lt

32nd ANNUAL MEETING

SEPTEMBER 5-8, 2021

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BIO-DERIVED FEEDSTOCKS FOR NATURAL DEEP EUTECTIC SOLVENTS

on this 8th day of September, 2021
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