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New eutectic mediums for biomass processing

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PURPOSE OF THE ABSTRACT

Wide introduction of biorefinery technologies is considered to be one of the plausible solutions for ecological issues caused by the intensive fossil fuels refinery: from global climate changes and CO2 pollution to local disturbance of ecosystems by mining or oil spills in oceans. Biorefinery utilizes abundant lignocellulosic supply to produce bulk and fine chemicals, and shows potential to substitute many of the oil originated compounds by thoughtful chemical transformations of all lignocellulose components. Besides, products gained from natural resources are often more environmentally friendly, like biodegradable lactic acid polymer or nanocellulose based composites.

Regardless the advantages of sustainability and lower environmental disturbance, the wide spread of biorefinery is hindered by the lack of technological schemes comparable or more profitable than fossil fuels processing. Oil and coal are the products of chemical transformations of the lignocellulose over millennia and in a way biorefinery is aimed to overcome the preserving stage of the fossil fuels formation and gain the chemicals used in modern industry directly from biomass or develop alternative materials. The high temperature/high pressure conditions, like those associate with fossil fuels formation in nature, combined with strong acids or bases to enhance the reactions, are most often used for biomass processing. We decided to use another natural approach for effective chemical transformation and use eutectic medium to host the biomass transformations. The eutectics are regarded as the third medium in living cell; they are composed of metabolites, and provide the liquid medium for reactions in extremely dry or cold conditions.

Forming the eutectic mixture is rather important for our approach, since it provides the depletion of melting temperature, which is mandatory to achieve chemical transformations in more reactive liquid state at lower temperatures. For this approach we decided on the ammonium salts of the most abundant acids (formic, acidic, lactic, etc.) produced by the hydrolysis of glucose, which will provide the sustainable precursors for the reactive eutectic mediums.

We applied the reactive eutectic medium for valorization of glucose into valuable pyrazine derivative used in food and tobacco industries. Similarly to water solutions, in eutectic mixture Maillard reaction of saccharides with ammonium species results in formation of glucosamine, subsequently dimerized to form disubstituted pyrazine derivative with distinctive smell. However, variety of possible Amadori transformations in aqueous medium lead to high variety of products, and pH control and catalysts are used to increase the primary transformation. Lack of water allowed having better control over the reaction pathway and maintains the predominance of the primary reaction, which resulted in yields up to 60%.

Similarly dihydroxybenzenes, used as model compounds of lignin decomposition products, were aminoformylated in one step in reactive eutectic medium composed exclusively of corresponding phenol and ammonium salt. Resulted aminoformylphenols are the building blocks for pharmaceutical and fine chemistry, which opens the direct path from natural phenols to nitrogen containing chemicals avoiding use of nitric acid and formation of hazardous amines.

We see a development of this concept in utilizing photocatalysts to facilitate chemical transformations within the eutectic medium in order to harvest more sustainable solar energy instead of high temperature approaches.

FIGURES

FIGURE 1

FIGURE 2

KEYWORDS
Deep eutectic solvents | Biomass conversion | Glucose valorization | Pyrazine derivative

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