IONIC LIQUIDS IN THE PRETREATMENT OF LIGNOCELLULOSIC BIOMASS

Ionic liquids (ILs) as solvents are defined as salts with a melting temperature below the boiling point of water (100°C). Similar to all salts, ionic liquids contain cation and anion (commonly in the form of organic cation and inorganic anion). ILs are typically liquid at room temperature, which makes them ideal solvents to work with.

IONIC LIQUIDS, A REMARKABLE CLASS OF GREEN SOLVENTS

Ionic liquids have been viewed as a remarkable class of "green solvents". Predominant advantages of ILs compared with traditional molecular solvents, are, e.g. broad liquid region, high thermal stability and negligible vapour pressure and no formed toxic or explosive gases released during utilisation. Besides, physical and chemical properties of ionic liquids can be designed for special applications by changing the constitution of anions or cations in ionic liquids. Depending on which anion and cation are chosen, their physical and chemical properties such as melting points, viscosity, hydrophobicity and hydrolysis stability are affected. Therefore ILs can be used in a variety of lignocellulosic biomass pre-treatment procedures.

CONSTITUENTS OF LIGNOCELLULOSIC BIOMASS

Major constituents of lignocellulosic biomass are cellulose 30-50 wt%, hemicellulose 15-30 wt% and lignin 10-30 wt%. Cellulose is a major component in plant cell walls, which is made up of 6-carbon sugar (glucose) in the form of long chains. Hemicellulose is composed of 5-carbon sugars (xylose) which is the second most abundant source in the plant cell walls, and it is interconnected with cellulose molecules. Furthermore, the third type of molecule is lignin, and it provides the structural strength for the plant. Due to the complex structure of lignocellulose, it is resistant to traditional solvents, which inhibits hydrolysis and commercial utilisation. Since different lignocellulosic materials have different physico-chemical characteristics, it is necessary to adopt suitable pre-treatment methods for lignocellulosic biomass.

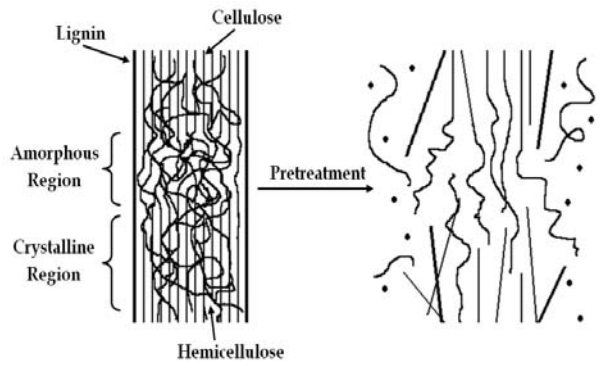

Figure 1. Goals of the pre-treatment adopted from Mosier et al. 2005.

PRE-TREATMENT OF BIOMASS

Biomass pre-treatment in ionic liquids is to decompose the fibre structure of lignocellulose and to utilise all the components (See Figure 1). The pre-treatment of lignocellulosic biomass can affect its physical properties, such as alter the structure of cellulosic biomass to make cellulose more accessible to the enzymes that convert carbohydrate polymers. Subsequently, when lignocellulose is separated into its components, it can be hydrolysed to fermentable sugars (monosaccharides) using mineral acids or enzymes. Monosaccharides can then be further converted to other valuable bio-based chemicals.

MOST COMMONLY USED IONIC LIQUIDS

The mostly reported ionic liquids that are used to dissolve lignocellulose are 1-Allyl-3-methylimidazolium chloride ([AMIM]Cl) and 1-Butyl-3-methylimidazolium chloride ([BMIM]Cl). The ions in [AMIM]Cl or [BMIM]Cl dissociate to individual cations and Cl- ions. The free Cl- ions associate with the cellulose hydroxyl proton, which are the hydrogen bond accepters and the free cations are moderate hydrogen bond donators that complex with the cellulose hydroxyl oxygen. This leads to the disruption of hydrogen bonds in cellulose and to the dissolution of cellulose. Figure 2 shows the form of cellulose in ionic liquid of [BMIM]Cl before and after the dissolution.

TYPICAL PRE-TREATMENT PROCESS

In the typical process of lignocellulose biomass pre-treatment, lignocellulose in ionic liquid are heated up to 100°C in a certain time. The dissolution time depends on the structure of cellulose and type of ionic liquid. The dissolved cellulose in the ionic liquid can be precipitated by adding a non-solvent (antisolvent), such as water, methanol, ethanol or acetone and be separated by filtration. The filtrated ionic liquid can be recovered and reused through the distillation of the antisolvent.

Recently, a variety of ionic liquids have been used to dissolve lignocellulosic biomass. The efficient ones, so far, are ILs commonly containing Cl- anion. Chlorine has been proved as an ecologically destructive element in the industrial utilisation and its by-products are also harmful for human. Therefore, finding new chlorine free ILs that also provide good dissolution ability on lignocellulosic biomass (cellulose, hemicellulose and lignin) is underway.

LITERATURE

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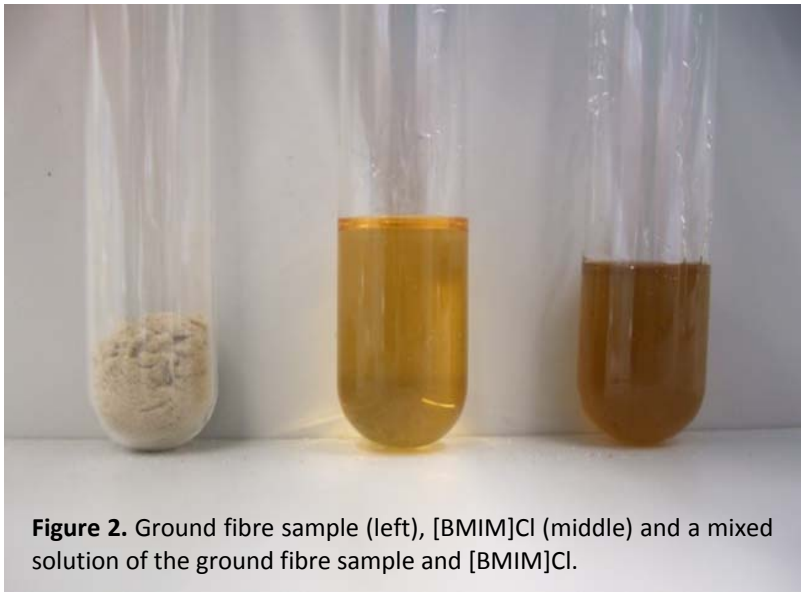

Figure 2. Ground fibre sample (left), [BMIM]Cl (middle) and a mixed solution of the ground fibre sample and [BMIM]Cl.

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19.11.2013

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