CHAPTER 7

Dicationic Acidic Ionic Liquid as Esterification Reaction Catalyst for Biodiesel Production

Asiah Nusaibah Masri, M.I. Abdul Mutalib,
Wan Zaireen Nisa Yahya, and Leveque Jean Marc Thierry

7.1 INTRODUCTION

Biodiesel, a clean renewable fuel, has shown a huge potential as one of the alternative sustainable sources of energy for the future. Compared to conventional diesel fuel, biodiesel emits fewer hazardous substances through the exhaust release as they do not produce sulphur and also known to produce zero net carbon dioxide from the total emission balance. Moreover, biodiesel emits smaller amount of carbon monoxide and particulate matters, as well as produces more oxygen (Fazal et al., 2011; Mohammad Fauzi & Amin, 2012; Silitonga et al., 2011). Esterification and transesterification are known to be the most favourable techniques for biodiesel synthesis due to their low investment and operating cost besides simple operation. Besides that, they offer several advantages including higher product cetane number, improved combustion performance resulting in lower emissions, and its renewability (Goodrum et al., 2003; Schinas et al., 2009).

Typically, there are several classes of biodiesel feedstock namely edible, non-edible, animal fats, waste, microalgal and fungi oil (Kumar & Sharma, 2015). Since the properties of the produced biodiesel are similar to those of conventional diesel, edible oils from palm, coconut, rapeseed, soybean and peanut were previously the main feedstocks used in the production of biodiesel. The plantations provide about 95% of the feedstocks required and were well-established in various countries such as Malaysia, Germany, and United States. However, the large-scale production may threaten local biodiversity and cause major environmental problem, as well as leading to supply shortage for food (Atabani et al., 2012; Yan et al., 2014).

Usage of non-edible oils including jatropha, pongamina, cumaru, neem as well as recently explored callophyllum inophyllum, as substitutes is seen as the solution to directly solve the food security issue (Handayani et al., 2017). Despite the fact that the inedible sources contain some deadly elements that make them unfit for human consumption, their plants can be grown in wastelands, eliminating the rivalry for space with food sources. Nevertheless, these oils have higher content of free fatty acids (FFAs) which is not good for biodiesel. Therefore, it must undergo few reaction steps to resolve the issue which escalates the operating cost (Patil & Deng, 2009; Sahoo & Das, 2009; Tiwari et al., 2007).

On the other hand, the use of animal fats including tallow, chicken fats as well as yellow grease as biodiesel feedstock, removes the requirement for their waste disposal. However, their poor yield and the presence of saturated fatty acids have hindered their application for massive biodiesel production. Waste oil or used frying oil (UFO) are seen to be more environmentally friendly and better sustainability but again the biodiesel produced possesses many undesired properties from the impurities presence from the originating oil. Due to the sources' widespread dispersal, the requirement for transportation and material gathering also presents serious challenges (Gui et al., 2008; Leung & Guo, 2006; Singh & Singh, 2010). Consequently, microalgal and fungi oil have emerged as another promising feedstocks as they could produce 30 times more oil and could be harvested within shorter time period compared to the other oil crops (Kumar & Sharma, 2014). However, due to the need for large-scale bioreactors and abundance-oil-generation algae species, its implementation would also have significant expenses for operation (Atabani et al., 2012).

Acid catalysts have a track record of achieving better yield of biodiesel than other types of catalysts because they can catalyse both trans- and esterification reactions simultaneously without generating soap. Hence, biodiesel may be produced using the low-cost feedstocks such as grease and used oil whereby the FFA composition is typically found to be above 6%. However, using conventional acid catalyst such as sulfuric acid may lead to significant equipment corrosion and environmental impact from its disposal (Masri et al., 2018a). Therefore, researchers are exploring new types of catalyst that provide similar advantageous whilst having greener properties and ionic liquids (ILs) have then been proposed (Han et al., 2018a; Han et al., 2018b).

ILs are molten salt presence in liquid form below 100 °C. Among the interesting properties of ILs are they are easily separable from the bulk feed/product solutions, could be reused or recycled and produce little waste by-product (Sulaimon et al., 2020). As a result, the reactions and purification steps for the biodiesel production could be shortened (Lin et al., 2015; Sheldon et al., 2002). Generally, increasing the acidity of ILs will