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Boiler Ash-Catalysed Synthesis of Glycerol Carbonate from Glycerol

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Abstract

Over the years production of glycerol as a crude waste from biodiesel making industries has been largely increasing. This is because for every 100 kg of biodiesel produced 10 kg of glycerol is produced as a by-product which corresponds to 10 weight percentage of biodiesel. It is estimated that by the year 2016, the production of crude glycerol will reach 4 billion gallons (Rahmat *et al*. 2010). Therefore, the market value of glycerol has dropped drastically over the recent years. To overcome this problem, the conversion of glycerol into valuable chemicals such as glycerol carbonate through an economical catalytic synthesis route is suggested herein. Glycerol carbonate has myriad uses where they play a major role as a component of surfactants, paints, coatings, gas-separation membranes, electrolytes liquid carrier and cosmetics (Aresta *et al.*, 2009; Sonati *et al.*, 2013). However the challenge does not only lie in the conversion but also focuses on usage of waste materials as the feedstock and as the catalysts. Malaysia is the second largest oil palm producer in the world and about 4 million tonnes of boiler ash is produced as waste from incineration of palm fruits, palm kernel, palm shells and palm fibers (Mohammed *et al*. 2005). Hence, the waste boiler ash (BA) was used as catalyst in this research. For that, a series of catalysts were prepared using various calcination temperatures. The reactions were conducted in triplicates and time online analysis (TOL) was conducted up to 10 hours (Figure 1) to determine optimum reaction time for production of glycerol. Lower yield observed at reaction time more than 4 hours is due to the decomposition of glycerol carbonate. Besides, the catalysts were characterized using XRD, TGA, ICP-MS, FESEM, FTIR, NH_3-TPD, CO_2-TPD and Hammett test. To add on, the highest catalytic activity obtained resulted in an average of 93% conversion of glycerol, 90% selectivity of glycerol carbonate and 84 % yield of glycerol carbonate (Figure 2) which was comparable with a recently reported study by Turney and co-workers in 2013 which stated yield of glycerol carbonate produced to be 83% using metal monoglycerolates (Metal MG) as catalysts. The catalytic activity of the boiler ash is influenced by synergistic effect of various metal ions such as potassium, magnesium, calcium and zinc that influences the acidic property of the catalyst which subsequently promotes the selective conversion of glycerol to glycerol carbonate. Moreover, the current research employed is of green synthesis route as it suggests proper utilisation of waste. Finally, it can be concluded that the study is also profitable as it entirely supports the concept of conversion from waste into wealth.

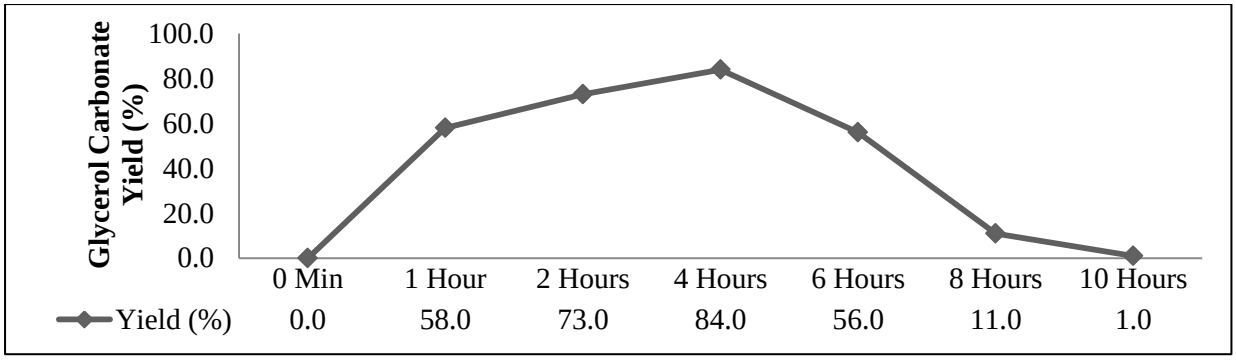
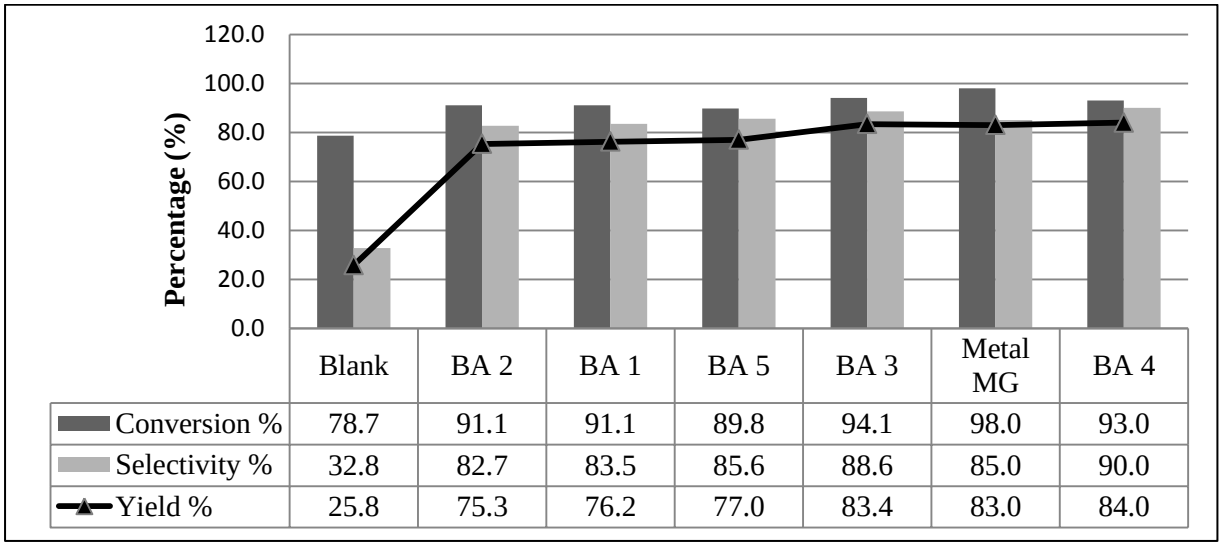


Figure 1: Time online analysis (TOL) of glycerol carbonate production.



	Blank	BA 2	BA 1	BA 5	BA 3	Metal MG	BA 4
Conversion %	78.7	91.1	91.1	89.8	94.1	98.0	93.0
Selectivity %	32.8	82.7	83.5	85.6	88.6	85.0	90.0
Yield %	25.8	75.3	76.2	77.0	83.4	83.0	84.0

Figure 2: Effect of Catalysts on conversion (%) of glycerol, selectivity (%) of glycerol carbonate and yield (%) of glycerol carbonate.

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