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An integrated system for fractionation and hydrolysis of sugarcane bagasse using heterogeneous catalysts in aqueous biphasic system

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Abstract

Sugarcane bagasse fractionation and hydrolysis using heterogeneous catalysts in aqueous biphasic system was investigated. Carbon-based, polymer-based and metal-based catalysts were synthesized and tested for hydrolysis of sugarcane bagasse in a combination of solvent-based and polymer-based aqueous biphasic system at different polarities for sugar production. The results showed that acid density, functional groups and physical properties of catalysts influenced the catalytic activity on cellulose hydrolysis. From solvent screening study, nitrobenzene was the most promising solvent enhancing relatively high total reducing sugar (TRS) yield of 97.4% when hydrolysis took place at 140 °C for 4 h in the presence of carbon-based catalyst type 1(C-SO_3H). Nevertheless in terms of recyclability, magnetic metal-based catalyst ($SO_4^{2-}/TiO_2/Fe_3O_4$) that yielded considerably high amount of glucose at elevated temperature and shorter time (180 °C 1 h) was suitable catalyst as it was easily separated from the solution. Kinetic study of cellulose hydrolysis reaction was performed, in which rate constant and activation energy of reaction catalyzed by active catalysts were compared. The results suggested an effective integrated system for cellulose fractionation and hydrolysis in which lignin-rich fraction was in solvent and polymer phases while cellulose fibers were remained in the aqueous phase and further hydrolyzed by heterogeneous catalyst.

Keywords: Lignocellulose saccharification; biphasic lignin separation; carbon-based catalyst; nanomagnetic metal-based catalyst; kinetic study; activation energy

1. Introduction

Sugarcane bagasse (SCB) is one of the most abundant agro-industrial lignocellulose residues in Thailand. Cellulose and hemicellulose are principle constituents in bagasse, and thus it has potential as a renewable resource for biorefinery processes via sugar platform through chemical and biochemical reactions [1]. Selective cellulose degradation using cell wall degrading enzyme complex provides very high sugar yield with high selectivity. However, to produce effective enzymes in industrial scale it requires genetic engineering and advanced biotechnology. Alternatively, acid hydrolysis