A review of catalytic upgrading of bio-oil to engine fuels

As the oil reserves are depleting the need of an alternative fuel source is becoming increasingly apparent. One prospective method for producing fuels in the future is conversion of biomass into bio-oil and then upgrading the bio-oil over a catalyst, this method is the focus of this review article. Bio-oil production can be facilitated through flash pyrolysis, which has been identified as one of the most feasible routes. The bio-oil has a high oxygen content and therefore low stability over time and a low heating value. Upgrading is desirable to remove the oxygen and in this way make it resemble crude oil. Two general routes for bio-oil upgrading have been considered: hydrodeoxygenation (HDO) and zeolite cracking. HDO is a high pressure operation where hydrogen is used to exclude oxygen from the bio-oil, giving a high grade oil product equivalent to crude oil. Catalysts for the reaction are traditional hydrodesulphurization (HDS) catalysts, such as Co–MoS2/Al2O3, or metal catalysts, as for example Pd/C. However, catalyst lifetimes of much more than 200h have not been achieved with any current catalyst due to carbon deposition. Zeolite cracking is an alternative path, where zeolites, e.g. HZSM-5, are used as catalysts for the deoxygenation reaction. In these systems hydrogen is not a requirement, so operation is performed at atmospheric pressure. However, extensive carbon deposition results in very short catalyst lifetimes. Furthermore a general restriction in the hydrogen content of the bio-oil results in a low H/C ratio of the oil product as no additional hydrogen is supplied. Overall, oil from zeolite cracking is of a low grade, with heating values approximately 25% lower than that of crude oil. Of the two mentioned routes, HDO appears to have the best potential, as zeolite cracking cannot produce fuels of acceptable grade for the current infrastructure. HDO is evaluated as being a path to fuels in a grade and at a price equivalent to present fossil fuels, but several tasks still have to be addressed within this process. Catalyst development, understanding of the carbon forming mechanisms, understanding of the kinetics, elucidation of sulphur as a source of deactivation, evaluation of the requirement for high pressure, and sustainable sources for hydrogen are all areas which have to be elucidated before commercialisation of the process.