Catalytic reductive depolymerization of wood lignin and waste plastics into chemicals

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Axe 6

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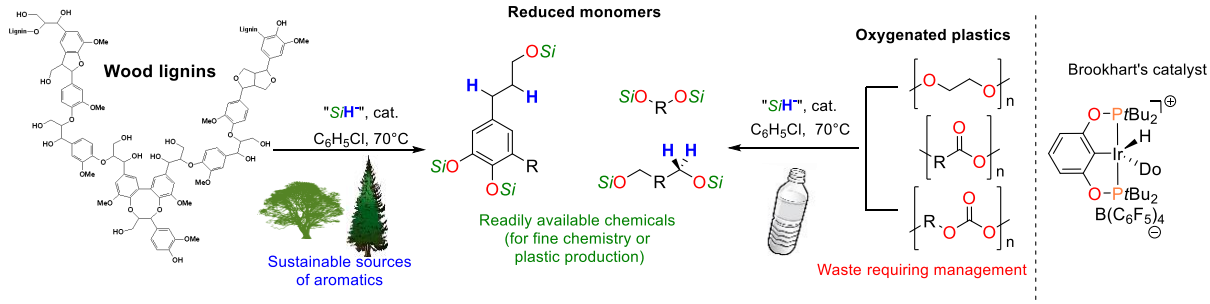
Most of the organic chemicals and 99,9% of the aromatics compounds are derived from petrochemistry. The deleterious environmental impact of human activities and depletion of raw material fossils impose the design of sustainable processes to decorelate the chemical industry from its fossil fuel dependance. It is thus crucial to find alternatives resources, natural and renewable, to access major intermediates for industrial applications and high added values chemicals. The future of chemical industry turns on the valorization of biomass together with the recyclability of matters. [1,2]

Wood lignin is an amorphous, polymeric and strongly ether-linked material, extracted in tons by paper industry and currently burnt for energy production. Because of its high content in aromatic compounds, this natural material has a huge potential for the production of aromatic chemicals in particular low molecular weight molecules (benzene, toluene, xylenes..) which market is estimated to be close to 100 billions in 2015. This is however a challenging task that requires a change of paradigm and the design of novel processes for the selective depolymerization of lignin into a limited number of molecules. In 2014, our laboratory reported a successful route for depolymerisation of lignin based on a convergent reducing route with silanes (reductants) and tris(pentafluorophenyl)borane $B(C_6F_5)_3$ as catalyst. By this way, a few number of pure aromatic compounds have been isolated for the first time from a variety of softwood (resinous trees) and hardwood (leaved trees) lignins.[3]

The ability to cleave strong C–O bonds by this approach was viewed as promising for the destructuration of other common oxygenated polymers and in particular for the management of a variety of manufactured oxygenated polymers. This route was succesfully applied to the depolymerization of oxygenated plastics containing ethereal, ester and carbonates moieties.

Because of the poor stability of the organic compound $B(C_6F_5)_3$ in common organic solvents, we searched its replacement with a more stable metal complex. Our choice focused on the Brookhart's iridium(III) complex which chemical behaviour in hydrosilylation is close to that of $B(C_6F_5)_3$ and we drawn comparizons between these two catalysts.[4]



Catalytic hydrosilylation of wood lignins (left) and oxygenated plastics (right) with iridium(III) complex

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1. F. G. Calvo-Flores et al, in *Lignin and lignans as renewable raw materials: Chemistry, Technology and Applications*, ed. C.V Steven, Wiley-Blackwell, **2015**.
2. a) PlasticsEurope: Plastics The Facts **2017**; b) World Economic Forum, Ellen MacArthur Foundation, The New Plastics Economy – Catalysing Action, **2017.**
3. E. Feghali, T. Cantat T., *Chem. Commun*., **2014**, *50*, 862. b) E. Feghali, G. Carrot, P. Thuéry, C. Genre, T. Cantat, *Energy Environ. Sci*., **2015**, *8*, 2734. c) E. Feghali, T. Cantat, *ChemSusChem*, **2015**, *8*, 980.
4. a) L. Monsigny, E. Feghali, J.-C Berthet, T. Cantat, Manuscript accepted in Green Chemistry; b) L. Monsigny, J.-C. Berthet, T. Cantat, Manuscript in preparation (for plastics).