We have developed a new reaction/separation technology based on a family of recoverable and recyclable nanohybrid catalysts that simultaneously stabilize emulsions in biphasic systems. These nanostructured solid particles exhibit a unique advantage in streamlining biomass refining, where the immiscibility and thermal instability of crude bio-oil greatly complicates purification procedures. These novel catalyst/emulsifier hybrids can catalyze reactions with high “phase-selectivity” either in the aqueous or organic phases. The amphiphilic-catalysts are obtained by fusing carbon nanotubes to metal-oxide particles, which results in a “Janus” like nanoparticle that is able to stabilize water/oil emulsions by forming a rigid film at liquid-liquid interface of the droplets, increasing the apparent viscosity of the system. The inorganic oxide may act both as the hydrophobic side of the emulsifier and as a condensation catalyst. Hence, it is able to catalyze condensation reactions in the aqueous phase, by which small oxygenates soluble in water, with low fuel value, condense via aldol-condensation, ketonization, or etherification. The resulting products are no longer water-soluble molecules and therefore migrate to the organic phase. The oxide used can vary in acid/base characteristics (e.g. MgO, SiO₂, TiO₂ and ZnO).

In the organic phase, transition metals (e.g. Pd, Ni and Cu) can be anchored onto the hydrophobic carbon nanotubes of the nanohybrids to catalyze deoxygenation reactions including hydrogenation, hydrogenolysis, or decarbonylation.

This unique approach could have a great impact in many industrial processes, such as bio-oil upgrading, and production of specialty chemicals and pharmaceuticals, where selective reaction and separation based on water solubility are desirable.
