Hydrothermally converted biomass for wastewaters treatment

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One of the major problems threatening the sustainability of the ecosystems is the degradation of the water resources quality due to the discharge of wastewaters from different industries in natural environment without appropriate treatment (Azzaz et al. 2018). These wastewaters may contain inorganic, organic and/or microbiological pollutants (Tewari et al. 2005). Various technologies were developed and tested in order to tackle this problematic such as coagulation-flocculation, membrane separation, biological treatment, advanced oxidation processes, etc (Freitas et al. 2015). Despite some good purification results, these techniques still present some limitations such as the exorbitant related costs, the important consumed energy amounts and the generation of toxic by-products (Islam et al. 2015). Pollutants adsorption onto chemically or thermally modified carbonaceous materials has been pointed out this last decade as an interesting research topic (Li et al. 2018). This technology, which is relatively cheap compared to other methods, has proved interesting removal efficiencies for various pollutants (Zhou et al. 2017).

In this context, hydrochars generated by hydrothermal carbonization (HTC) of wet biomasses have been highlighted as a promising solid matrix for various pollutants removal from wastewaters even under complex experimental conditions (Benavente et al. 2015). Compared to the pyrolysis process, the HTC method does not necessitate a pre-drying step, as water is considered as a reaction media. Furthermore, the exothermic tendency of the HTC reaction causes the transformation of the intrinsic moisture present in the feedstock into water vapor which further enhances the carbonization of the feedstock. On the other hand, the quick change in the water phase causes a dramatic increase in the reactor inner pressure varying between 2 and 10 MPa.

Large varieties of feedstocks such as lignocellulosic residues, agricultural residues, animal wastes, municipal wastes, WWTP activated sludge and food processing by-products have been hydrothermally carbonized under controlled conditions and their impacts onto the by-products (bio-oil, biogas and hydrochar) generation percentages as well as their physico-chemical characteristics were assessed (Ruan et al. 2018).

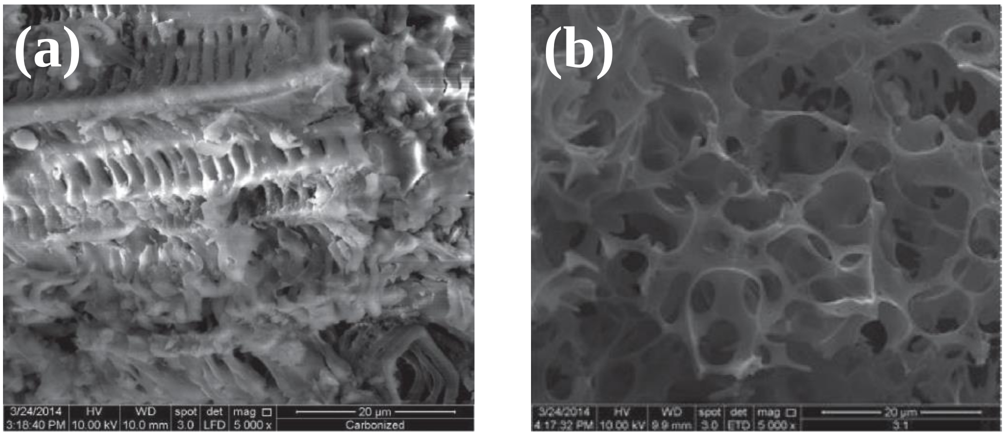

Figure 1: Factory rejected tea (a) before and (b) after hydrothermal carbonization and chemical activation using NaOH solution (Islam et al. 2015)

Besides, various studies have pointed out that the carbonization temperature, the residence time, the heating gradient and liquid to solid ratio are the main parameters that determine the final physico-chemical properties of the produced hydrochars and therefore their applicability for wastewaters treatment (Sun et al. 2016; Ronix et al. 2017).

The adsorption of various number of pollutants onto hydrochars such as dyes (Islam et al. 2017; Qian et al. 2018), heavy metals (Zhou et al. 2017; Li et al. 2019) and organic pollutants and pesticides (Eibisch et al. 2015; Liang et al. 2017) were investigated. Results showed interesting removal capacities, varying between 35 to 96%

(Zhu et al. 2016; Han et al. 2017). Higher efficiencies are often obtained with hydrochars that have undergone specific modifications that have enhanced their surface properties in terms of specific surface area and functional groups concentration.

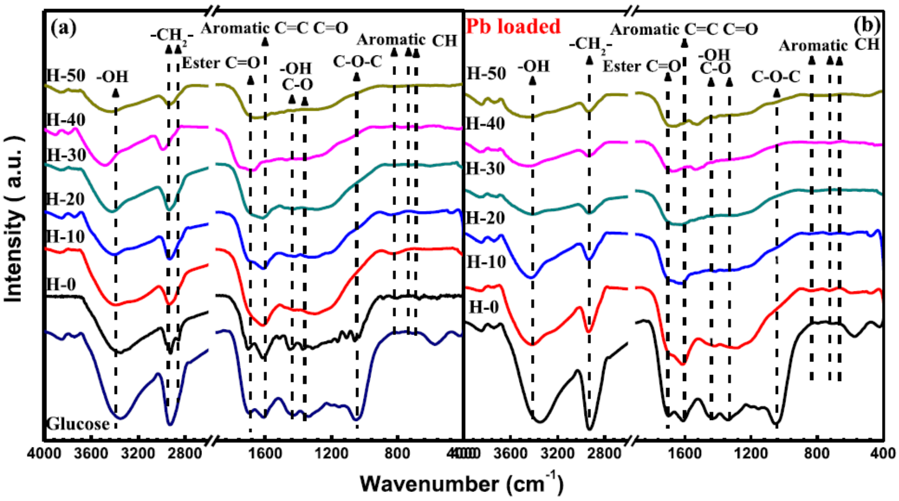

Figure 2: FTIR spectra of (a) pure and (b) Pb loaded hydrochar (Zhou et al. 2017)

Adsorption mechanisms of various studied pollutants were also investigated based on the type of the targeted molecule and/or ion. The authors pointed out that adsorbates were generally adsorbed by combination of various mechanisms, mainly physisorption, chemisorption and intra-particle diffusion (Islam et al. 2017). They might involve n-π and π-π* covalent bonding characterized with increasing free energy (Enthalpy), as well as an electronic affinity with carboxylic and phenolic functional groups present on the hydrochars surface (Ruan et al. 2018).

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