Cascade use of lignocellulosic wastes through slow pyrolysis.

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Project context and objectives

Residual agricultural biomass possesses great potential utilization in providing renewable sources for producing energy and materials. One such use is through the utilization of slow pyrolysis technology to convert biomass into rich carbonaceous biochar, effectively gaining energy densification, while also obtaining the byproduct (pyrolysis liquid, also called wood vinegar) as a potential agent for wood protection. Pyrolysis itself is a thermochemical conversion of organic materials by using heat in an oxygen-deficient environment. This process breaks down biomass components, producing solid (char, also called biochar), liquid (bio-oil), and gas fractions (Mohan et al 2006). By adjusting pyrolysis process parameters, such as temperature level, heating rate, and residence time, the quantity of the most desired products can be controlled (Carrier et al 2011). From several types of pyrolysis, slow pyrolysis refers to a method that uses a relatively lower heating rate (<80 °C/min), medium temperature (usually between 300 °C–500 °C), and longer residence time (hours /days), offering a favorable balance of mass yields (Ronsse et al 2015). In most cases, slow pyrolysis is primarily intended for charcoal production, with organic vapors often being discarded as waste. However, due to its large composition of bio-active chemicals such as acids, phenols, furans, and guaiacols compounds, the recovery of this type of condensable organic vapors is already of interest for many applications, such as insecticide and fungicide for wood protection systems (Boer et al 2021).

In Iran, a substantial amount of agricultural and industrial lignocellulosic wastes is generated annually with limited utilization to enhance their value-added potential. These wastes are commonly incinerated, either for disposal purposes or to produce thermal energy. For instance, approximately two million tons of sugarcane bagasse are annually produced in Iran, of which only half is utilized for natural fiber production. Additionally, Iran is a significant production hub for dried fruit seeds like almonds, walnuts, and pistachios, where the hard shells of these seeds can serve as valuable sources for wood vinegar and biochar production.

The aims of this project are to use Iranian plant biomass considered as wastes and that are for the moment mainly burnt for energy and/or landfilled. The selected biomass(es) can be pyrolyzed (slow pyrolysis) in order to create 2 items: biochar and pyrolysis oil (also called pyrolysis liquid, bio-oil or wood vinegar). The biochar will be characterized for its composition and performances to allocate it to a specific use (energy, carbon storage in soil, etc..). The main challenge of this project will be to use at its best the wood vinegar: it should be characterized, refined (distilled, purified), used to treat wood or any lignocellulosic material (composites). Its efficacy as a wood protection system will be evaluated through ageing tests and biological tests

towards both fungi and termites. The objectives are to shift from waste plant biomass to added value products (bio-char, wood protection product) using a technology already available in Iran and France (slow pyrolysis), to encourage a circular economy system.

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