Valorization of (semi-)dry Agri-Food Wastes by Torrefaction

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Biomass wastes, specifically agri-food residues, are more and more valued as sources of bioactive substances and candidates to the production of biofuels, either solid or liquid or gas. Various agri-food residues were taken into consideration in this work to subtract them to bare disposal and to candidate them to become solid biofuels by torrefaction. This work is the result of both contract-funded projects and laboratory partnership among cooperating institutions in the Campania region (IT). The feedstocks taken into consideration originated from hazelnut (leafy husks and roasted cuticles) cherry (industrial cherry cake) and grapes (mark, stalks and seeds).

An experimental program was dedicated to fluidized bed torrefaction on a 38 mm ID lab-scale facility. The methodology addressed the issues of handling “difficult” biomass particles, such as feeding partly wet solids, reducing the original size and fluidizing them smoothly and homogeneously as a batch in a bed of inert particles. The test plan spanned the torrefaction temperature at three levels (200, 250 and 300°C) under a constant residence time (5 min), and then extended the residence time (10 and 20 min) in *ad hoc* tests. A drawback induced by the biomass torrefaction mechanism, i.e., the definitive "capture" of the small bed inert solids on the surface of the particles undergoing torrefaction, was overcome by a bed switch from fine but rather heavy solids (100-250 μm quartz sand) to coarser and lighter ones (expanded clay 1000-1400 μm).

As a first exploitation of the results, the methodology of the regression analysis was pursued to develop simple mathematical correlations describing the usual performance indexes of the main torrefaction product (solid biochar) and the yield of the secondary product (torgas) as a function of temperature and residence time.

As a further ongoing exploitation of the results, the methodology of Artificial Neural Network (ANN) modeling is being pursued. The ANN encompasses an input layer managing the feedstock properties and the torrefaction operating variables, and returns an output layer predicting the torrefaction performance indexes and the properties of torrefied solids as a fuel. This approach leverages the innovative issue of data augmentation through Gaussian noise addition to a relatively scarce

experimental dataset. Such an expanded dataset already proved a great improvement in the ANN prediction performance. A work is ongoing to assess the robustness of the model and to possibly predict the performance of new feedstocks, e.g., some ones not considered by the authors so far.

Keywords: *torrefaction, agri-food residues, fluidized bed, Artificial Neural Network, empirical correlation*