Regeneration of Valuable Materials from Poultry Farm Wastes

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Trash and wastes are important issues, and result from our modern lives. These anthropogenic processes inevitably produce minor undesired products along with major intended ones. The intermingling of these minor products with natural resources triggers the accumulation of wastes, and the accumulation of wastes means inefficient utilization of resources. This leads to eventual environmental pollution and ultimate release of heat.

Waste is also a broad category, varying from minute household garbage to huge amounts of industrial residues. One of them is agricultural and livestock wastes which can also be called biomass wastes. Agricultural biomass and animal wastes have been used for secondary generation of feedstuff in the food pyramid. Animal biomass is generally comprised of proteins which can be readily distinguished from cellulosic biomass (Mante and Agblevor, 2010). Therefore, they actually contain precious materials. The intrinsic structure and morphology of these materials opens a route into biomaterial applications other than their direct use for poultry and pet feeds (Senoz and Wool, 2011), and high value-added products can be created for other purposes. In this way, farmers have a chance to earn higher incomes. The application of thermochemical conversion processes on these fine materials can produce various types of materials such as porous scaffolds (Ji et al., 2014).

The keratin-based biomaterials offer many superior properties. The avian feathers, especially from poultry and specifically chicken ones, are the most important keratin-based animal wastes (Figure 1). Recently rigorous studies were executed on them to produce various type of materials (Tuna et al., 2015). Feather chemical composition is shown in Table 1.

Figure 1. Chicken feathers from slaughter wastes.

The effect of heat application and the result of temperature gradients on the matter produces amazing solid, liquid and gaseous products (Caglar and Aydinli, 2010). This conversion is called pyrolysis, which is a basic thermochemical process. In pyrolysis, the reaction is executed in a stationary environment without any physical intervention. Thus the intrinsic structure can be preserved, while the rest of the organic material elements (H, N, O) other than carbon are eliminated. This generally results in a carbon-based porous solid powder.

The regenerated materials were examined morphologically and elementally by scanning electron microscope (SEM) and X-ray Florescence (XRF). The heat can affect the protein structure to produce resilient materials. Temperature is a very good variable in changing the structure of these materials. The porosity can be critically controlled by temperature resulting in

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various morphologies as shown by SEM figures. Here, solid materials were obtained from the poultry feathers by pyrolysis (Figure 2).

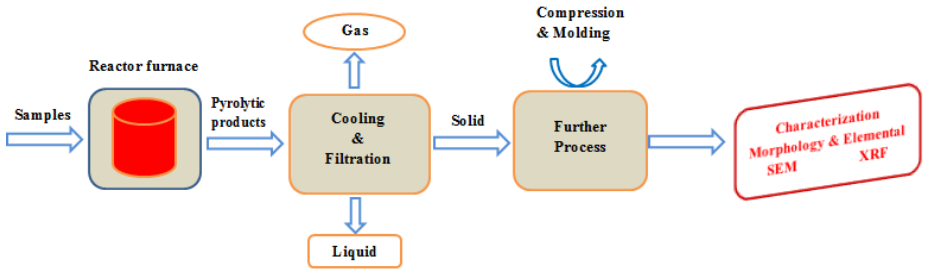

Figure 2. The pyrolysis process setup.

A nascent feather is shown in Figure 1, while SEM photographs of it appear in Figure 3a and 3b. The feather has a fine longitudinal structure, that can be exploited to obtain precursor materials. In consideration of the keratin composition, the thermochemical conversion process applied on it can produce Nano tubes (Senoz and Wool, 2010). The porous structure in Figure 3d reveals that the porosity and the morphology can be basically altered with temperature (Figure 3c) and also possibly catalysts and processing conditions. Unfortunately the well-grown precursor material did not yield the desired porous and fibrillary structure. The morphology of this ultimate material is shown in Figures 3e and 3f, where the photos were taken of both the surface and fractured surface of the compressed pyrolysis powder. There are also other methods such as electrical and sol-gel, that have not yet been explored in this research project.

Table 1. Some important elements obtained from XRF analysis of feathers.

Element	Na	Mg	Al	Si	P	S	Cl	K	Ca	Fe
%	0.91	0.07	0.02	0.08	0.24	1.39	0.35	0.24	0.60	0.13

In summary, an attempt was made to transform natural fine waste to high value-added materials which may open a high income gate to farmers. The possible application of these materials includes medicines, space technologies, and the entire polymer technology industry.

References

Boyle, J.F. 2010. Rapid elemental analysis of sediment samples by isotope source XRF. J. Appl. Polymer Sci. 118: 1752-1765.

Caglar, A., and B. Aydinli. 2010. The catalytic effects of potassium dichromate on the pyrolysis of polymeric mixtures part I: Hazelnut shell and polyethylene oxide and their blend cases. Intl. J. Chem. Molec. Nucl., Mat. Metallurg. Engrg. 4(8): 457-461.

Ji, Y., J. Chen, J. Lv, Z. Li, L. Xing, and S. Ding. 2014. Extraction of keratin with ionic liquids from poultry feather. Separ. Purif. Tech. 132: 577–583.

Mante, O.D., and F.A. Agblevor. 2010. Influence of pine wood shavings on the pyrolysis of poultry litter. Waste Mgmt. 30: 2537-2547.

Senoz, E. and R.P. Wool. 2011. Hydrogen storage on pyrolyzed chicken feather fibers. Intl. J. Hydr. Energy 36(12): 7122-7127.

Senoz, E., and R.P. Wool. 2010. Microporous carbon–nitrogen fibers from keratin fibers by pyrolysis. J. Appl. Polymer Sci. 118(3):1752-1765.

Tuna, A., Y. Okumus, H. Celebi, and A.T. Seyhan. 2015. Thermochemical conversion of poultry chicken feather fibers of different colors into microporous fibers. J. Analyt. Appl. Pyrolysis 115: 112-124.

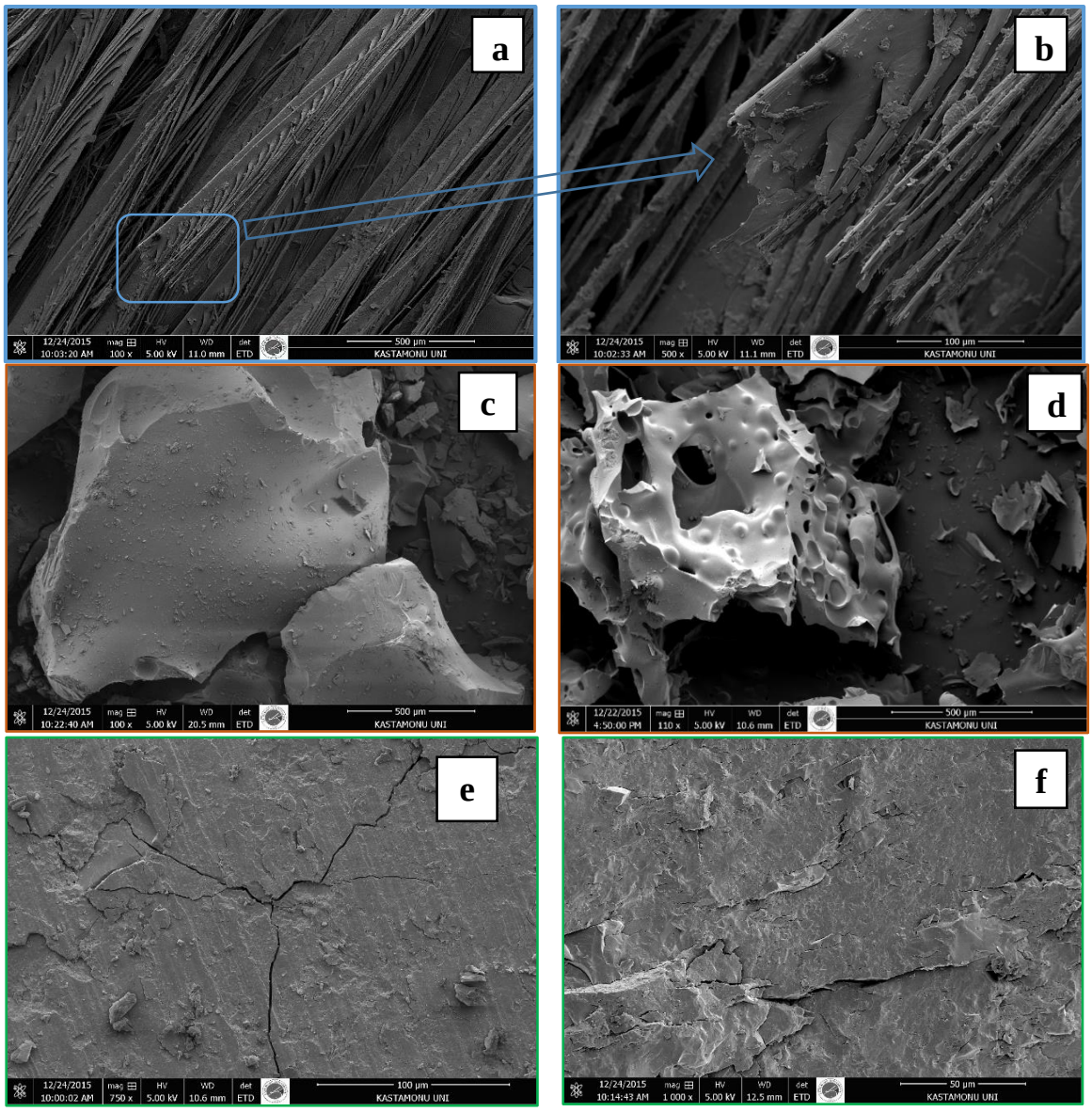

Figure 3. SEM images of a & b - unprocessed chicken feathers at two magnifications, c & d - pyrolysis of solid powder at two different temperatures (400 & 650^{o} C), and e & f - surface and fractured surface of compressed chicken feather material (650^{o} C).