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Food wastes as raw materials for humidity sensing

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Food production, processing, marketing, consumption, and disposal have an important environmental impact because of energy and natural resources use and embodied greenhouse gas emissions [1].
More than 11 billion tons/year of coffee are consumed and used coffee grounds end up in landfills as municipal solid wastes. Rice is the most consumed food in several countries and it is the major by-product from rice milling (1.2 billion tons per year worldwide). Rice husk ash (RHA) derives from the unwashed husk and contains about 96 wt% of silica. Both food wastes were investigated as humidity sensing materials.
Waste brewed coffee powder was first pyrolysed at 700 °C in nitrogen atmosphere. Then, sensors were manufactured by screen-printing technique. Their response to water vapour was studied in a relative humidity (RH) range from 0 to almost 100% at room temperature. The sensor impedance under dry air was equal to 23-25 MΩ and starts to decrease from 20 RH%, exhibiting a n-type semiconductor behaviour. The response and recovery times were quite fast when RH value changed from 0 to 50% (15–20 s), and the cross-sensitivity to CO_2, NH_3, NO_2 and O_3 was negligible.
Rice husk ash was fired at 500 °C for 3 h prior to sensors screen-printing and firing at 600 °C for 1 h. When exposed to water vapor at room temperature, the thick-film's impedance value decreased from 18.6 MΩ under dry air to 213 kΩ under 93 RH%, displaying a n-type semiconducting behavior. At low humidity level, the impedance change was small, while above 25 RH% the impedance of the sensor decreased sharply with the increase in humidity content. When RH level changed from 0% to 93%, the response time was equal to 15 s, whereas the recovery time was equal to 23 s. In addition, cross-sensitivity tests carried out towards NH_3, CH_4, CO_2, N_2O and O_3 showed no interference.
These two examples illustrate the potentialities of food wastes as candidate humidity sensing materials.

[1] *Food wastage footprint, 2013, http://www.fao.org/3/i3347e/i3347e.pdf*
[2] *P. Jagdale et al. Sens. 19, 2019, 801, 1-14*
[3] *D. Ziegler et al. Sens. & Actuators, 328, 2021, 129049*

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