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ORIGINAL ARTICLE

Kinetics and physical analyses for pyrolyzed Egyptian agricultural and woody biomasses: effect of microwave drying

Mahmoud Amer[1,2] · Mohamed Nour[3,4] · Mahmoud Ahmed[5] · Ibrahim El-Sharkawy[5] · Shinichi Ookawara[6] · Sameh Nada[4,5] · Ahmed Elwardany[1,2]

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Abstract

This paper investigates microwave drying effect as a pretreatment method on the kinetic parameters of four torrefied biomasses. The considered biomasses are rice straw, rice husk, sugarcane, and cotton stalks. Dried samples (microwave or oven-dried) were then torrefied under isothermal conditions in a thermogravimetric analyzer (TGA) at two different temperatures of (250 and 300 °C). Two simple kinetics methods were applied including direct Arrhenius (DA) and Coats and Redfern (CR). The physical structure of rice straw and cotton stalks as a function of drying method and torrefaction temperature has been studied using Brunauer–Emmett–Teller (BET) surface area technique. Results revealed that microwave drying increased both the activation energy and the pre-exponential factor for both rice straw and sugarcane regardless of the torrefaction temperature, while the opposite occurred for rice husk. In the case of cotton stalks, microwave drying increased the kinetic parameters at 250 °C and decreased them at 300 °C. The activation energy and pre-exponential factor values obtained from CR method were larger than the ones from DA method. The 300 °C torrefied, conventionally dried rice straw has the lowest activation energy and pre-exponential factor and the largest peak width indicating wide range of reactivity. While microwave dried sugarcane, torrefied at 250 °C, is the hardest one to react. All microwave dried samples require more heat to decompose regardless of the torrefaction temperature. Microwave drying increased the surface area, mean pore diameter, and pore volume for rice straw, while the opposite occurred for cotton stalks due to its woody nature.

Keywords Pyrolysis kinetics · Biochar · Torrefaction · Microwave drying

✉ Ahmed Elwardany
ahmed.elwardany@ejust.edu.eg; ahmed.elwardany@alexu.edu.eg

[1] Fuels and Combustion Engines Laboratory, Energy Resources Engineering Department, Egypt-Japan University of Science and Technology (E-JUST), New Borg El-Arab City, Alexandria 21934, Egypt

[2] Mechanical Engineering Department, Faculty of Engineering, Alexandria University, Alexandria 21544, Egypt

[3] School of Mechanical Engineering, Shanghai Jiao Tong University, Dongchuan Road 800 Shanghai 200240, China

[4] Mechanical Engineering Department, Benha Faculty of Engineering, Benha University, Benha, Qalubia 13512, Egypt

[5] Energy Resources Engineering Department, Egypt-Japan University of Science and Technology (E-JUST), New Borg El-Arab City, Alexandria 21934, Egypt

[6] Department of Chemical Science and Engineering, Tokyo Institute of Technology, Tokyo 152-8552, Japan

Nomenclature

TGA	Thermogravimetric analyzer
CR	Coats and Redfern
QCD	Carbon quantum dots
CD	Conventional drying
FWO	Flynn-Wall-Ozawa
DSC	Differential scanning calorimetry
RH	Rice husk
CS	Cotton stalks
HHV	Higher heating value
E	Activation energy
t	Time
DA	Direct Arrhenius
BET	Brunauer–Emmett–Teller
MWD	Microwave drying
AEDM	Activation energy distribution model
DTA	Differential thermal analysis
RS	Rice Straw

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