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Reconstructing the kinetics of biomass pyrolysis from bio-components contributions: application to rice husk

E. Benedetto[1], V. Piazza[1,2], A. Guarnieri[1], M. Y. Suleiman[3], L. C. Pariani[4], P. D'Arrigo[4], T. Faravelli[4], A. Frassoldati[4], L. Lietti[1], A. Beretta[1], P. Debiagi[3]

[1]Politecnico di Milano, Dipartimento di Energia, Milan, Italy, [2]Politecnico di Milano, Milan, Italy, [3]University of Nottingham Ningbo China, Ningbo, China, People's Republic of, [4]Politecnico di Milano, Dipartimento di Chimica, Materiali e Ingegneria Chimica, Milan, Italy

Understanding biomass pyrolysis kinetics is essential for the optimization of thermochemical conversion processes; however, whether the pyrolysis behavior of real lignocellulosic biomass can be reliably described through an additive kinetic approach, which forms the basis of lumped kinetic models, remains a key open question. In this work, the adequacy of this hypothesis is investigated by focusing on the pyrolysis of a real biomass, namely rice husk.

The study starts with the experimental investigation of rice husk pyrolysis by thermogravimetric analysis coupled with mass spectrometry (TG-MS), providing detailed information on devolatilization behavior and product speciation [1][2]. The rice husk sample was then characterized through chemical fractionation, allowing the quantification of its main constituents. The individual pyrolysis behaviors of these constituents were combined additively according to the fractionation results and directly compared with the experimental evidence obtained for rice husk. In parallel, previously developed lumped kinetic models for the single constituents were also combined according to the experimentally determined biomass composition, enabling the evaluation of the capability of the additive modelling approach to reproduce the behavior of a real feedstock. The comparison between experimental TG-MS data and model predictions shows that the additive kinetic model satisfactorily reproduces both the overall devolatilization profile (Fig1) and the main trends in product speciation of rice husk pyrolysis, with only minor discrepancies. These results provide strong and encouraging evidence that additive lumped approaches can effectively describe the pyrolysis of real lignocellulosic biomasses. Ongoing work is focused on the detailed investigation of possible interactions among biomass components through the study of binary and ternary mixtures.

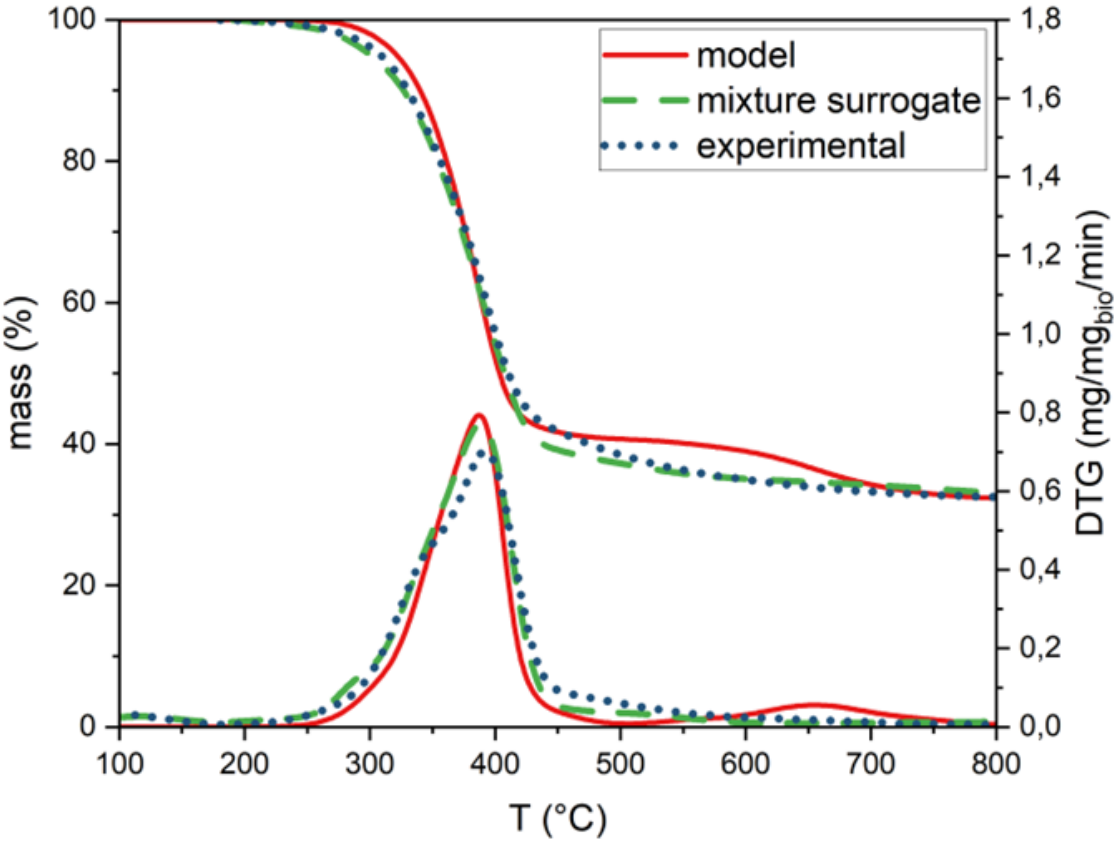

Fig.1: TG and DTG curves for rice husk: comparison between experimental data and predicted behavior by mixture surrogate and CRECK-S model

References:

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[2] Muhammad Yusuf Suleiman, Eleonora Benedetto, Veronica Piazza, Luca Lietti, Alessio Frassoldati, Tiziano Faravelli, Alessandra Beretta, Paulo Debiagi, (2025), Kinetic modelling of biomass pyrolysis: A new lumped scheme for xylan-based hardwood hemicellulose, Energy Conversion and Management: X, 101130, https://doi.org/10.1016/j.ecmx.2025.101130