ASEC 2025 Conference

The 6th International Electronic Conference on Applied Sciences

09–11 December 2025 | Online

MDPI

Effects of Process Variables in Watermelon Seed Oil Methyl Ester Production Catalyzed by Kaolin-Based Zeolite

Ahmed Tijani Ahmed[1,2*], Akor Hillary Ilemona[2,3], Miroslav Variny[1]

[1]Department of Chemical and Biochemical Engineering, Faculty of Chemical and Food Technology, Slovak University of Technology in Bratislava, Slovakia

[2]Department of Chemical Engineering, Confluence University of Science and Technology, Osara, Kogi State, Nigeria

[3]Department of Chemical Engineering, Federal University of Technology, Minna, Niger State, Nigeria

INTRODUCTION & AIM

- The Fourth Industrial Revolution (4IR) drive is accompanied by substantial advancements in the use of technological materials, resulting in a massive increase in the quest for a waste-free environment.
- Watermelon seeds, often discarded as agricultural waste, are a readily available byproduct that can be valorized through biodiesel production as an alternative to fossil fuel, reducing waste while contributing to renewable energy goals and circularity principles. Zeolite offers a generous surface area and an improved pore system that increases the reaction rate.
- This study is focused on investigating the use of zeolite refined from kaolin clay as a heterogeneous catalyst in biodiesel production using watermelon seed oil.

Table 1. Availability and biodiesel performance of some virgin feedstock

Feedstock	Oil content (wt %)	Conversion type methanol: oil	Temperature (ºC)	Time (min)	Catalyst	Biodiesel Yield (%)
Tobacco seed	35 – 49	Mild pyrolysis	350	NA	NA	67
Oleander	60 – 65	Transesterification 4.5:1	60	30	KOH	93
Cotton seed	17 – 23	Transesterification 6:1	40	60	KOH	96
Mahua seed	35 – 50	Transesterification 5:1	65	60	KOH	91
Tung seed	30 – 40	Transesterification 5:1	55	60	KOH	93
Candlenut	60 – 65	Transesterification 5:1	40	45	-	99.3

METHOD

- Development of a zeolite catalyst from kaolinite
- Beneficiation of raw kaolin
- Preparation of metakaolin (metakaolinisation)

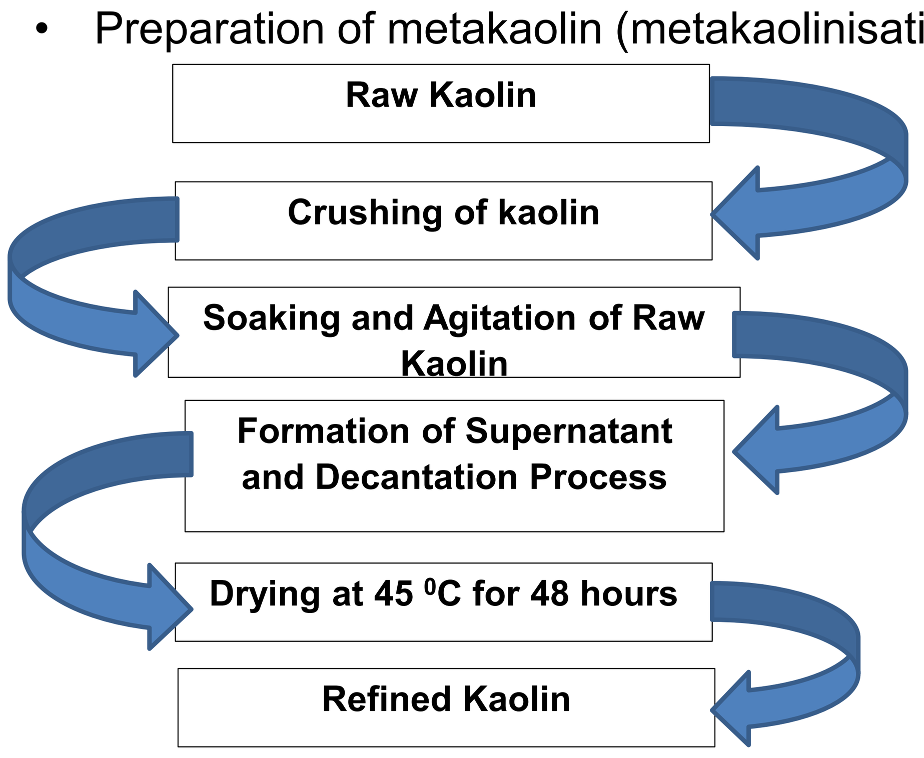

Figure 1: Schematic Diagram for Refinement of Kaolin

- Biodiesel Production

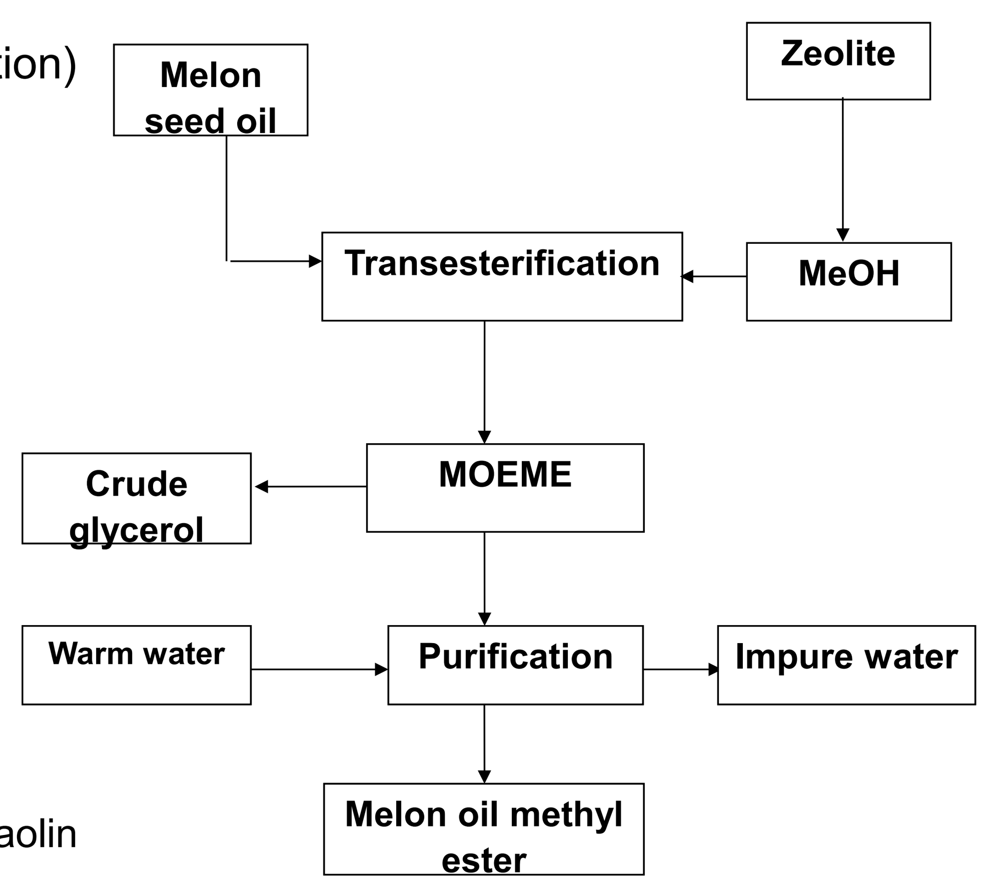

Figure 2: Flow Diagram for Biodiesel Production

- Characterization of melon oil and Methyl Ester

RESULTS & DISCUSSION

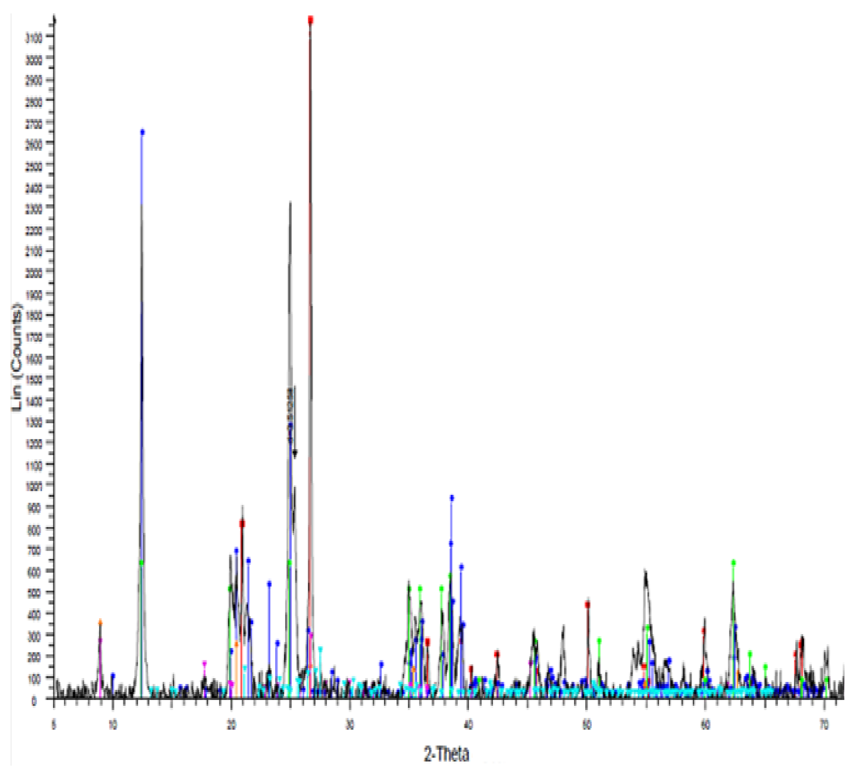

Figure 3: XRD Pattern of Raw Kaolin

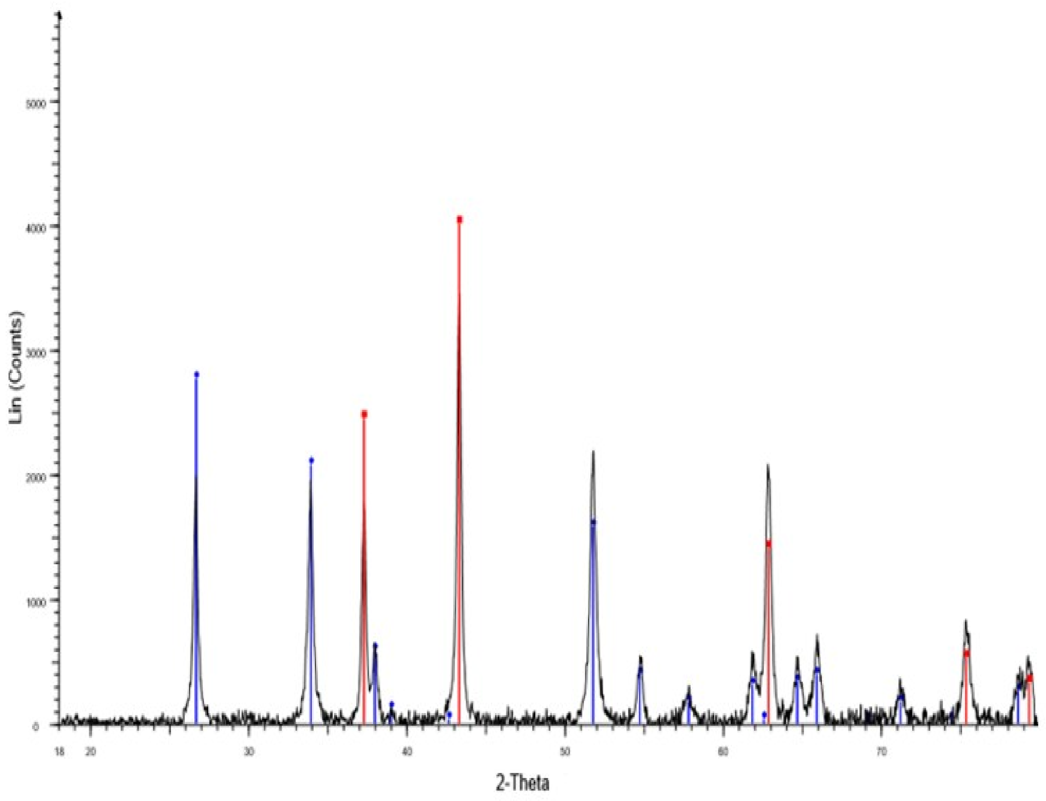

Figure 4: XRD Pattern of Beneficiated Kaolin

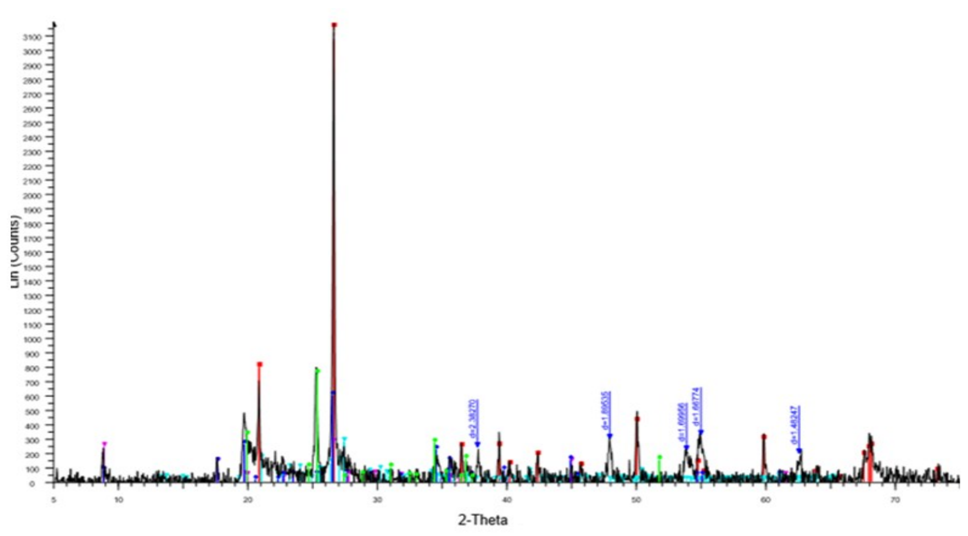

Figure 5: XRD Pattern of Metakaolin

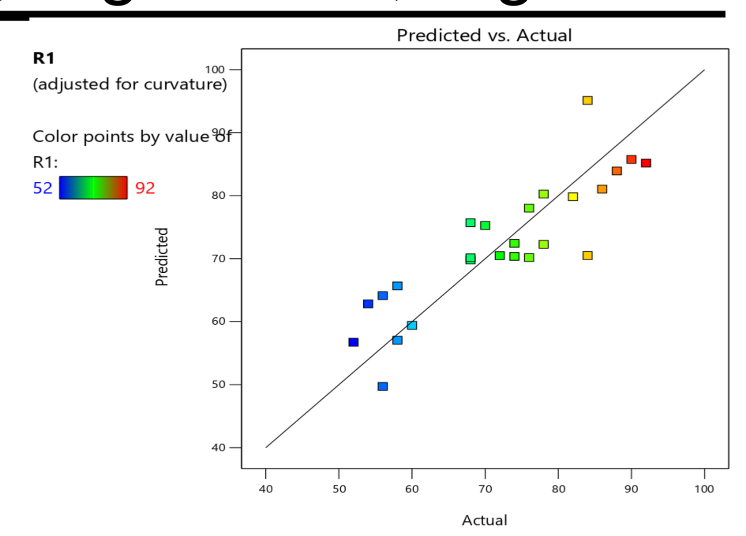

Figure 6: Predicted Biodiesel Yield against Actual Biodiesel Yield

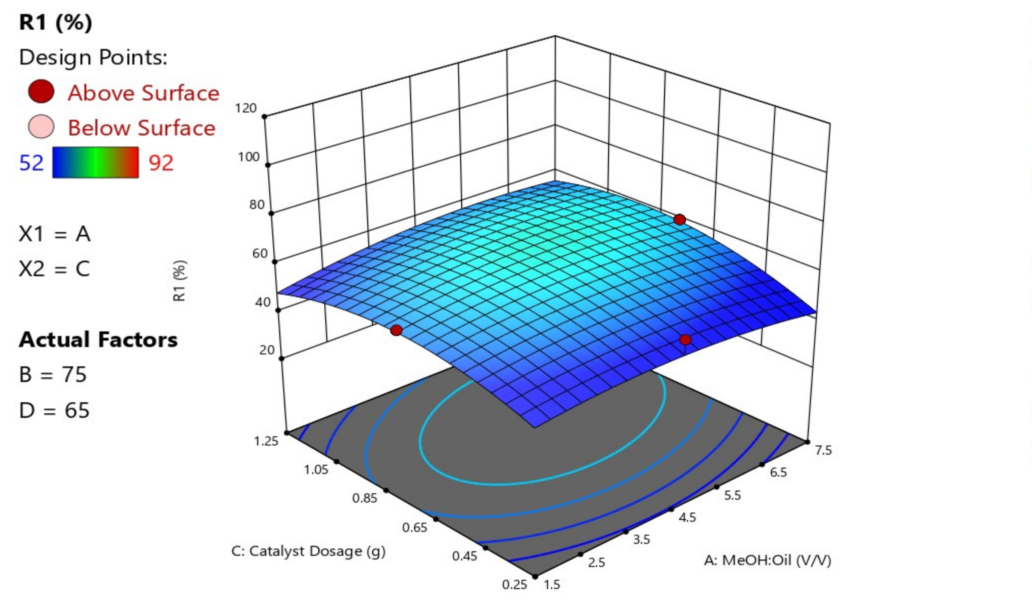

Figure 7: 3D Surface Interaction Effect of Catalyst loading and Methanol to oil ratio

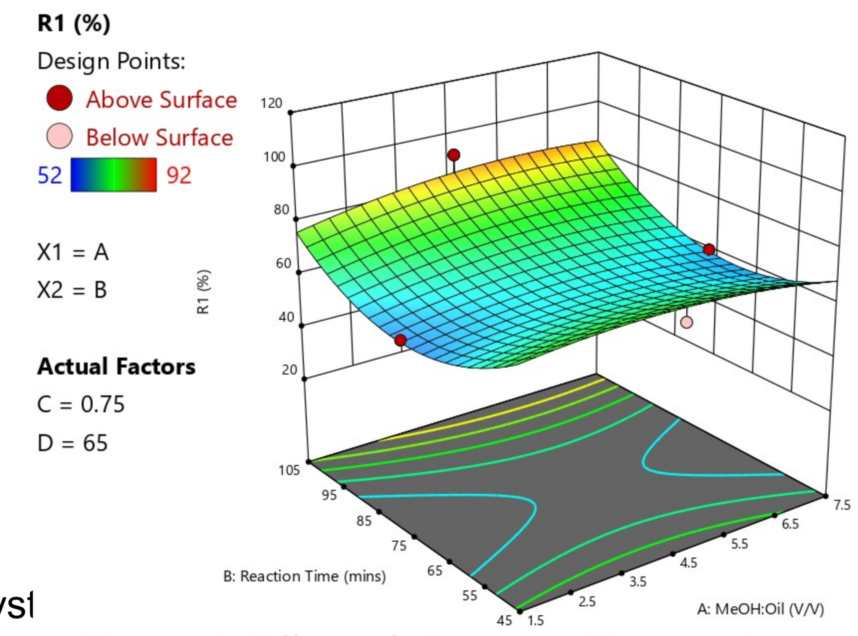

Figure 8: Effect of Reaction Time and Methanol to Oil Ratio

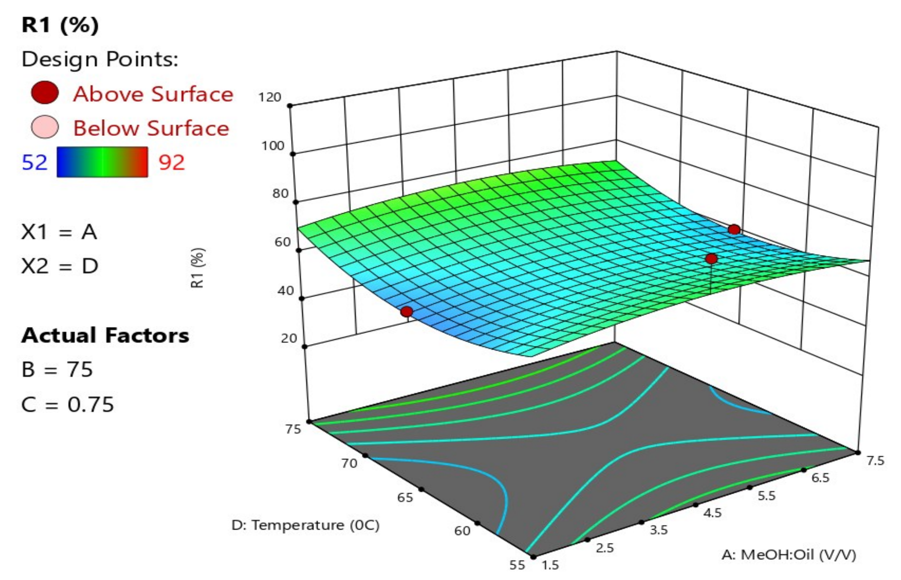

Figure 9: Temperature and Methanol to oil ratio on biodiesel yield

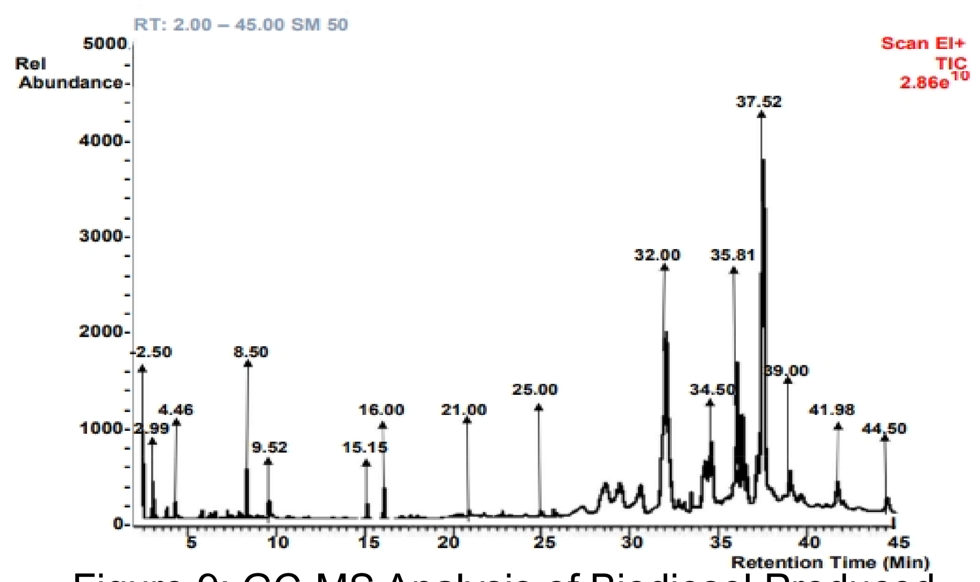

Figure 9: GC-MS Analysis of Biodiesel Produced

Table 2: Physicochemical Properties of Biodiesel Produced

S/N	Properties/units	Produced Biodiesel	ASTM Method
1	Density 40ºC (g/cm^3)	0.8946	D 4052
2	Moisture content	0.05	D4442
3	Cetane number	62.4	D613
4	pH	7.1	D445
5	Acid number (mgKOH/g)	0.74	D664
6	Kinematic viscosity (mm^2/s)	4.4	D6751
7	Free fatty acid (%)	0.37	D1982
8	Flash Point (ºC)	156	D93
9	Cloud point (ºC)	6	D2500
10	Pour point (ºC)	9	D97
11	Calorific value (KJ/kg)	43636	E11-87

CONCLUSION

The study on the Effects of Process Variables using Kaolin-Based Zeolite as Heterogeneous Catalyst in Watermelon Seed Oil Methyl Ester Production has demonstrated that zeolite possesses remarkable catalytic activity and stability, making it a promising alternative to conventional homogeneous catalysts. The utilization of watermelon seed oil, a non-edible and underutilized feedstock, presents a sustainable approach to biodiesel production, reducing dependence on food-based oils and contributing to waste valorization. The transesterification process catalyzed by zeolite produced appreciable yields of methyl esters with desirable fuel properties that meet standard biodiesel specifications.

FUTURE WORK

This work established a foundation for further optimization and scale-up, paving the way for eco-friendly, cost-effective, and sustainable biodiesel production from unconventional feedstocks.