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ZEOLITE SYNTHESIS FROM INDUSTRIAL WASTE FOR BIO-OIL PRODUCTION

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Abstract:
In recent years, due to the escalation in global energy consumption, the impact of the conversion biomass-to-fuel processes have attracted the attention of scholars and policy makers. In this perspective, the production of bio-oil via pyrolysis process is an attractive method to achieve certain qualities of bio-oil. However, pyrolysis oil is less desirable due to high oxygen content, low calorific value and high water content, therefore, catalytic co-pyrolysis is introduced due to its numerous advantages. Although various catalytic systems have been evaluated for its production, the recent interest have indicate a shift towards industrial waste as another approach to improve the qualities of catalytic co-pyrolysis. The review therefore comprehensively explored the role of utilizing coal fly ash, woody biomass ash, palm oil mill fly ash, and sugarcane bagasse fly ash as heterogeneous catalyst for bio-oil production. In zeolite synthesis, concentration of alkaline source, temperature, reaction time, liquid/solid ratio and type of waste determine the structural properties, Si/Al ratio and its applications. The main characteristics and the applications of these synthesized waste zeolites are also reported. The paper further discussed the progress in terms of process mechanism and identification of active sites.

***Keywords*:**
Bio-Oil; Industrial Wastes; Catalytic Co-Pyrolysis; Zeolite Synthesis; Pyrolysis Process.

Objectives:

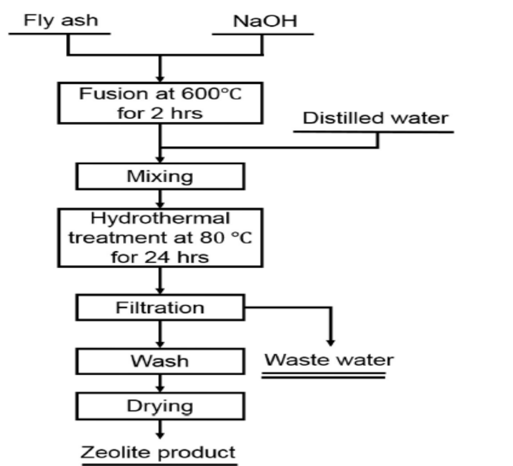
- To review research focusing on each application of waste materials for their benefits in the improvement of biomass-derived bio-oil
- To improve the bio-oil quality and high yield of bio-oil

Methodology:

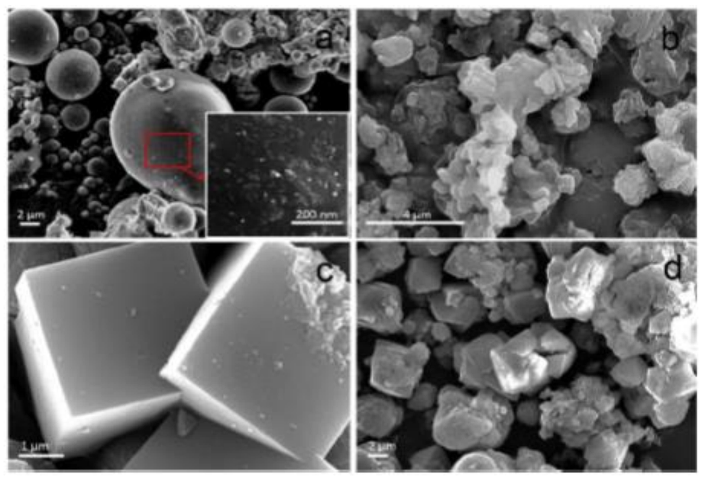
In order to collect data for this study, a systematic and extensive search was conducted for peer-reviewed academic articles published in the year 1998 to 2020 period, with extra information provided from external sources such as government and market-research sources. The search is conducted by several sets of keywords in various academic databases. The database that are included: Science Direct, Research Gate, JSTOR, SpringerLink, Elsevier, and Britannica, including the keywords, “co-pyrolysis and biomass”, “catalytic co-pyrolysis”, “bagasse ash as zeolite”, ”biomass ash as zeolite”, “coal fly ash as zeolite”, “palm oil ash as zeolite”, “production of plastic”, “production of biomass”, “heterogenous catalyst”. Result were selected which are related and is cited and referenced in this paper for brevity.

To supplement the peer-reviewed studies, literature and data from national ministries, major international research institute, and references from institutional report have been included to access on publicly reviewed statistics and information. The uses of various and multiple resources expand and ensure the mix of perspectives. The issues presented in the paper is applicable for zeolites used for catalytic co-pyrolysis of bio-oil.

Result :

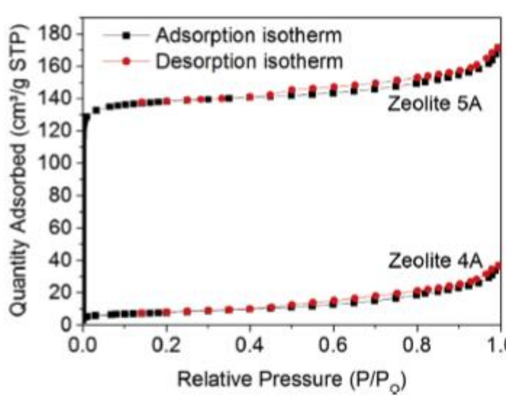


Hydrothermal Treatment for zeolite production

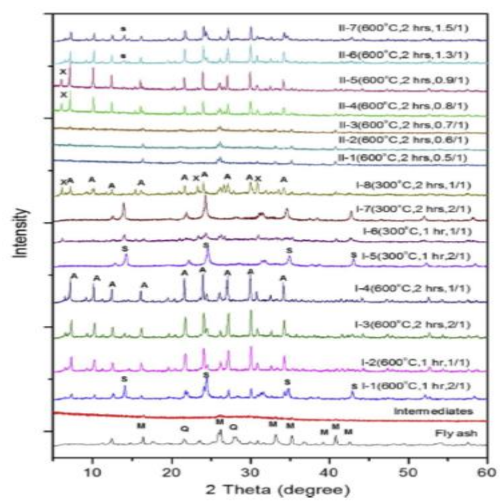


SEM images of a) fly ash, b) intermediates, c) zeolite 1-4, d) zeolite 1-8

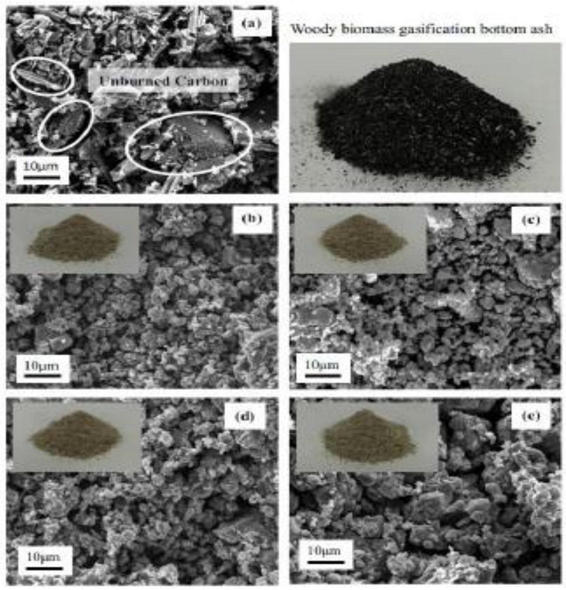
Items	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	II-4	II-5	II-6	II-7
S_{BET}-4A (m^2/g)	25	27	26	27	38	115	44	161	33	28	26	25
S_{BET}-5A (m^2/g)	124	440	376	471	34	117	30	331	341	408	405	360



BET surfaces areas analysis and the adsorption and desorption of Nitrogen in zeolite



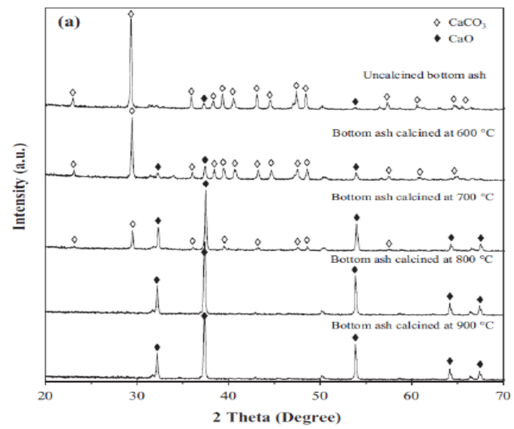
XRD patterns analysis under different conditions



SEM images of a) raw bottom ash, and ashes after calcination at different temperatures: b) 600℃, c) 700℃, d) 800℃, e) 900℃

Samples[a]	Elemental composition[b] (weight %)								Surface area[c] (m^2/g)	Total pore volume[c] (cm^3/g)
	C	Ca	Na	Mg	Mn	K	Fe	Zr		
Raw bottom ash	32.4	62.44	1.19	1.14	0.12	0.45	2.10	0.16	–	–
600BA	–	89.65	2.29	2.07	0.57	1.50	2.89	1.06	9.21	0.0702
700BA	–	89.02	2.99	2.13	0.66	1.60	2.09	1.51	9.06	0.0653
800BA	–	90.12	2.54	2.48	0.44	1.18	2.05	1.19	8.98	0.0621
900BA	–	90.23	2.11	2.54	0.53	0.91	2.48	1.20	8.23	0.0498

[a] 600BA, 700BA, 800BA and 900BA is bottom ash calcined at 600, 700, 800 and 900 °C, respectively.
[b] Analyzed by EDX analysis.
[c] Measured by BET analysis.



Physical properties of woody biomass and the XRD patterns calcined at different temperatures

Conclusion:

Researchers have studied and published various types of synthesis method to produce zeolites from industrial wastes such as coal fly ash, woody biomass ashes, palm oil mill fly ash and bagasse fly ash. These zeolites have been synthesized to enhance the production as well as the quality of bio-oil. The result of these studies shows that these wastes contain Si and/or Al which are essential material to synthesize zeolite as well as its properties and applications which are similar with the commercial zeolite. The main methods to synthesize the waste zeolites are common hydrothermal method, wet impregnation method and other hydrothermal treatment. The morphology of the zeolization from waste is based on Al and Si decomposition, crystalline structure, and other properties. The important synthesis parameter are the amount of Si and Al, reaction temperature, pressure, zeolite acidity, retention time and others. The type of waste zeolite synthesizes are reported. Based on the studies reported, coal fly ash contains low Si content however with proper treatment it can act as a best zeolite for catalytic process. For the woody biomass ash, it can be observed CaCO3 in the biomass ash can be completely convert to CaO when undergoes calcination. CaO is essential to bring significant changes to turn the strong acid sites into weak or less strong acid sites, which is beneficial for the increase in the product selectivity. The palm oil fly ash as a zeolite have the mesoporous structure which can prevent the obstruction of active sites on the zeolite which increase the selectivity of the zeolite. For sugarcane bagasse ash, it has potential applications in adsorption and catalysis due to the quartz abundant and as silicon source.