Ecofriendly Syntheses of Mesoporous Silica from Coal fly-ash for waste water treatment

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Background

Mesoporous silica materials have always represented an exceptional dominance in the field of material synthesis owing to the exploitation of their superior surface properties. Different approaches have been developed to synthesize mesostructured silica materials using chemical sources like silicon alkoxide (silicon tetraethoxysilane) as the typical silicon source and expensive structure directing agents. However, in response to the growing environment concern, sustainability issues associated with the silica precursors, nowadays ordered mesoporous silica (OMS) materials have been synthesized from industrial wastes like Coal Fly ash used as the silica source. It not only makes the entire synthesis process cost-effective which is the emergent need of material synthesis but caters to deal with the problem of waste disposal associated with the coal power plants. Since the synthesized silica materials are efficient adsorbents so they can be effectively utilized for the treatment of waste water discharged into the environment as industrial waste that contains toxic organic and inorganic chemicals and causes serious soil and water pollutionIn this regard, the current work discusses the greener and sustainable synthesis of mesoporous silica nanostructures and employing their use for waste water treatment.

Objectives

Synthesis of mesoporous silica materials obtained from coal fly ash for the waste water treatment

Materials and methods

Pluronic P123, tetraethoxysilane (TEOS) were obtained from Sigma Aldrich. CFA utilized in the present study has been obtained from Larsen & Toubro Super Thermal Power Plant (NPL), India. Sodium hydroxide, Hydrochloric acid were received from Loba Chemie, India and used without further purification.

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Coal Fly ash (CFA)

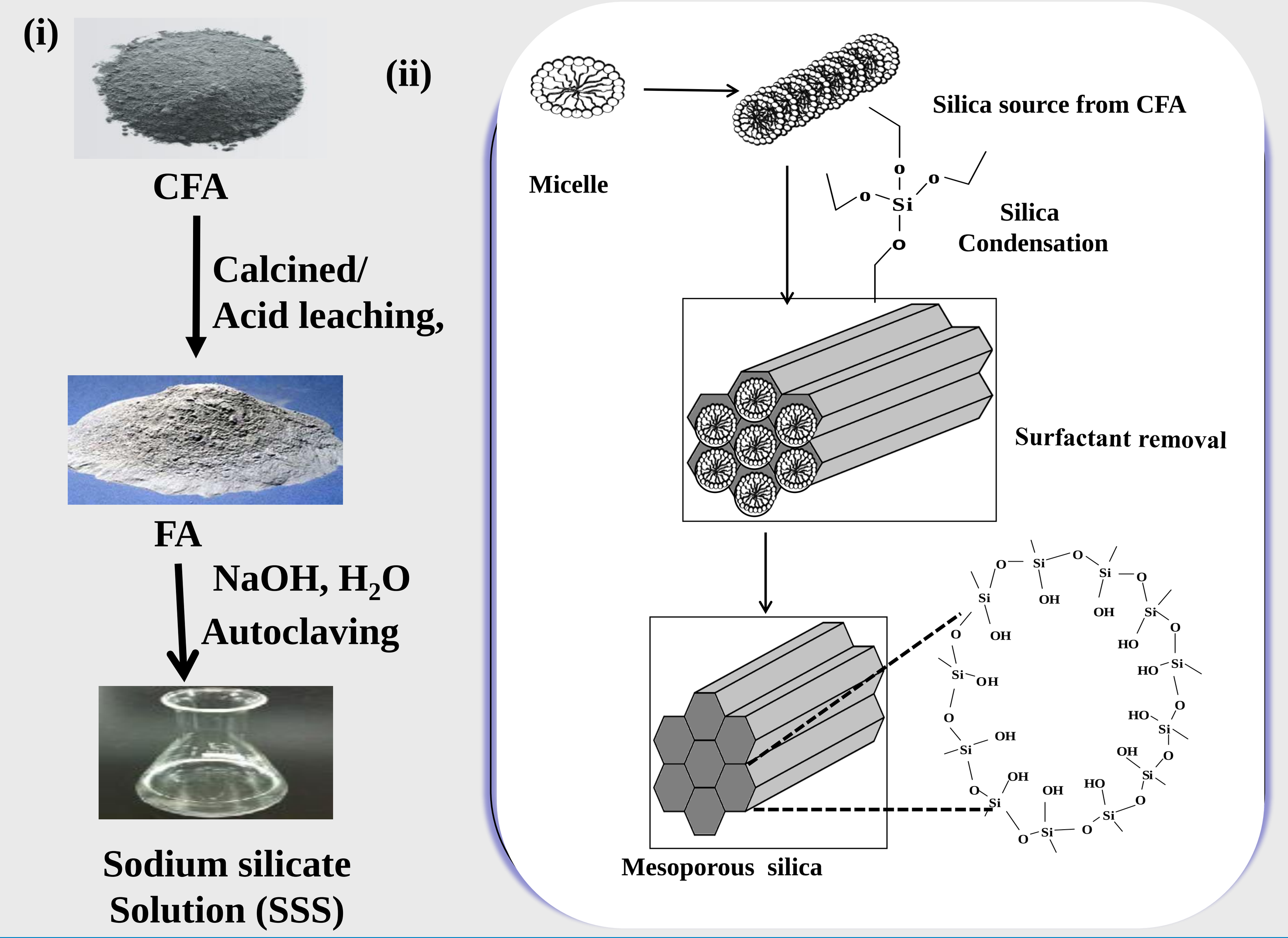
Characteristics

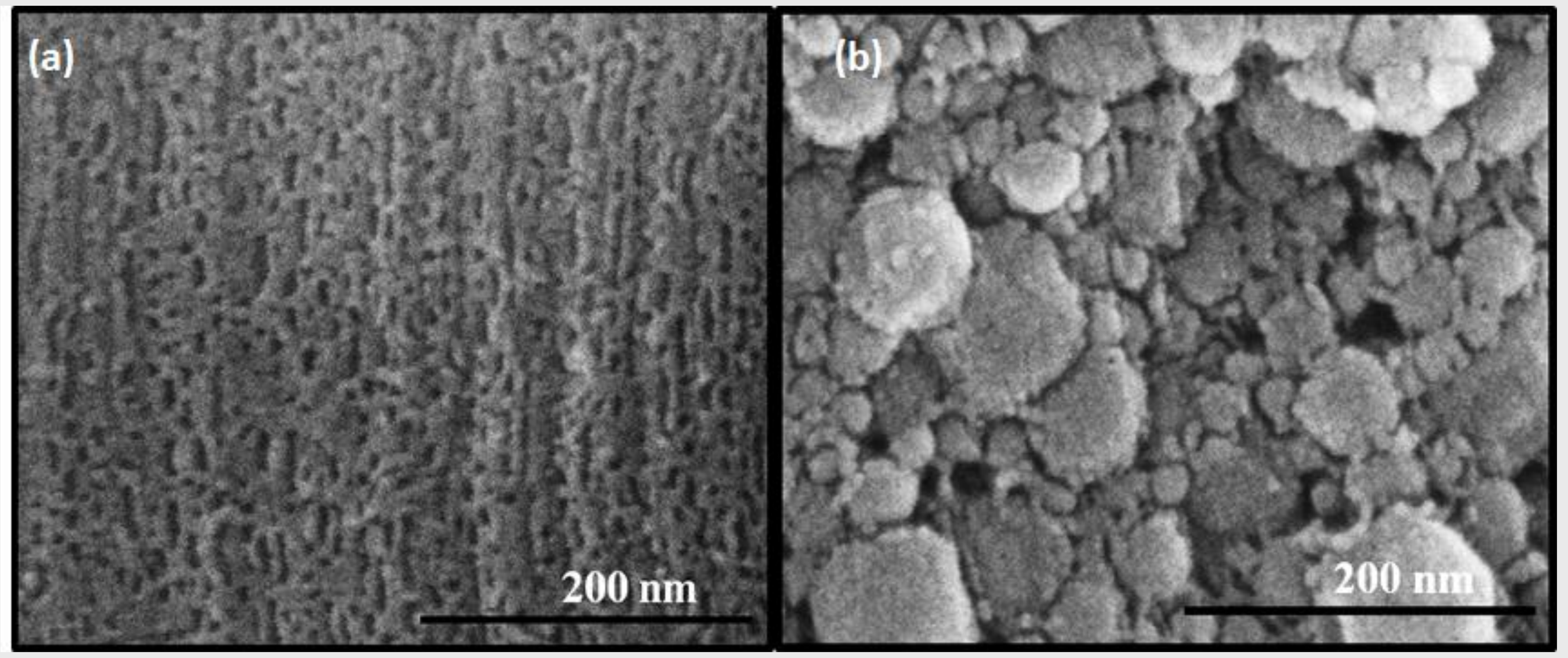
- Fine, grey amorphous byproduct of combustion of coal
- constitutes 5-20 wt.% of feed coal and occurs as coarse bottom ash and Fine fly-ash (85-95 % of total ash generated)
- consists of fine particles (average size < 20 μm), high surface area (300~500 m^2/kg), and higher water holding capacity
- the major chemical components are **SiO_2 and Al_2O_3** (60–70 wt.% and 16–20 wt%). So, resource recovery from coal fly ash is one of the most important issues in waste management at present

Applications

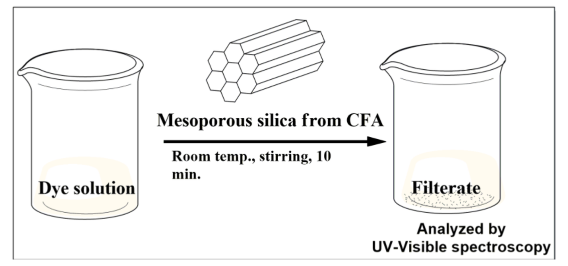
- Soil amelioration (buffering soil pH, enhancing soil organic matter content, and increasing crop yield)
- Construction Industry (as a raw material in the cement industry, roadway basements)
- Catalysis (catalyst and catalytic support)
- Zeolite synthesis
- Adsorbent

(i) Extraction of Silica from Coal Fly ash (CFA) and (ii) Synthesis of mesoporous silica from CFA



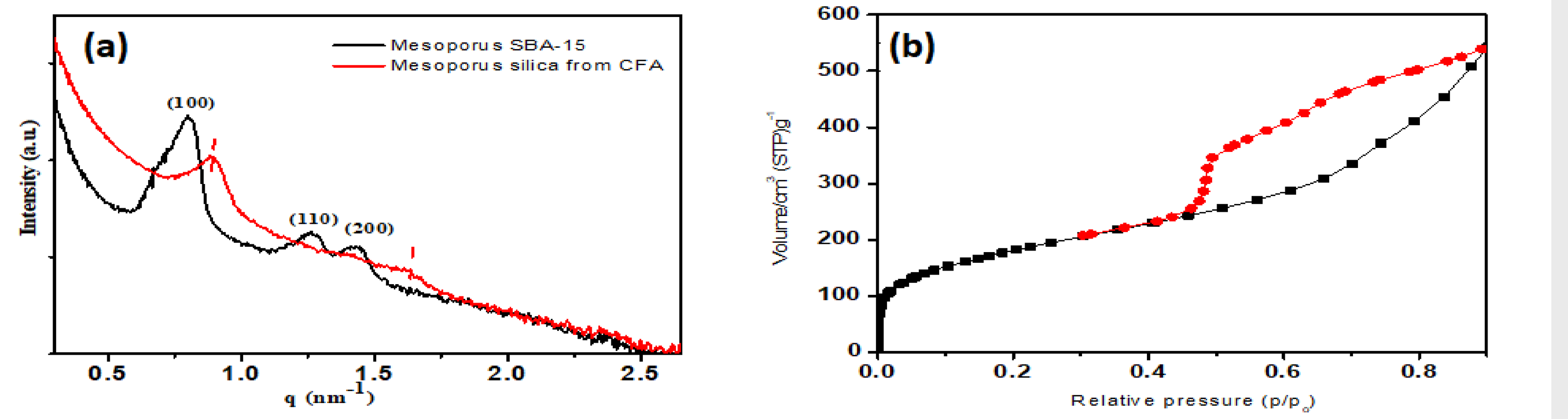


FE-SEM images of (a) MesopOrous SBA-15 and (b) mesoporous silica prepared using CFA



Reaction conditions: 10 mg adsorbent + 100 mL of Methylene blue (MB) dye solution (5 μM), contact time of 10 min, and temperature of 25 °C

- *The mesoporous silica prepared using CFA as silica source showed improved adsorption efficiency for the adsorption of methylene blue dye . The adsorption capacity increased with the increase in the pH of the solution.*
- *At an alkaline pH 9 the surface of mesoporous silica becomes negatively charged due to more hydroxyl ions. Consequently, the electrostatic interaction between the negatively charged mesoporous silica surface and the positively charged dye molecules increases resulting in enhanced adsorption capacity.*



Sample	q (nm)-1	d-spacing, d_{100} (nm)	unit cell parameter, a_o (nm)[a]	wall thickness, d_w (nm)[b]	Surface area	Pore volume	Pore diameter (nm)
Mesoporous silica from CFA	0.86	7.26	8.38	1.12	493	0.56	4.5

(a) SAXS profiles, (b) Nitrogen sorption isotherm and surface structural parameters for Mesoporous silica prepared using CFA

SUMMARY

- The FE-SEM images indicated that the mesoporous SBA-15 matrix comprised of long cylindrical channels as well as smaller crumpled cylindrical segments of different lengths divided by fine silica walls or constrictions also known as plugs.
- The FE-SEM image of Mesoporous silica prepared using CFA as silica source depicted the disordered pore structure with fused silica walls as confirmed by the nitrogen adsorption-desorption isotherms
- The nitrogen sorption isotherm of Mesoporous silica prepared using CFA is type IV with H4 hysteresis loop at p/p_o ~0.45–0.85 related to narrow slit pores.
- The SAXS data showed that the mesoporous silica structures obtained using CFA as a silica source resulted in a smaller pores and more disordered pore structure. This fact is evidenced by the decrease in the intensity of the peaks corresponding to the 100 and 200 planes in the prepared materials in comparison to the mesoporous SBA-15. Apart from this the 100 peak is displaced to larger values and the fact is related to the decrease in the lattice parameter of these samples.

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