

Optimizing Silica Extraction from Botswana Coal Fly Ash: Removal of Methylene Blue, Adsorption Process Analysis and Modelling

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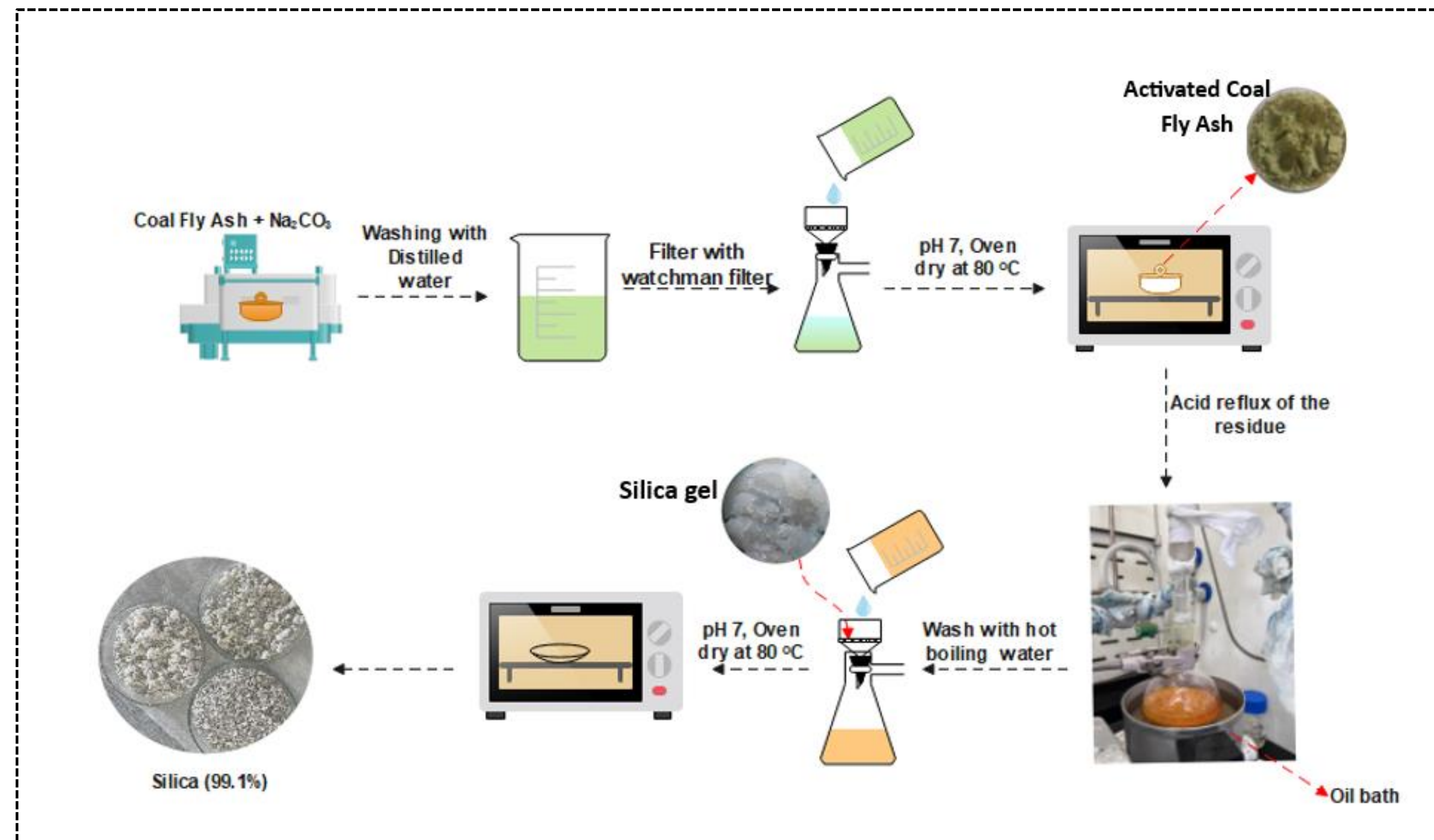


INTRODUCTION AND OBJECTIVE

Coal fly ash (CFA), a solid waste byproduct of coal combustion in thermal power plants, represents a valuable resource due to its rich content of silica and alumina (1). Coal fly ash pose significant environmental challenges. Improper disposal and accumulation of fly ash on undeveloped land have adverse effects, including soil degradation and threats to both human health and ecosystems (2). Groundwater contamination by heavy metals, disruption of natural drainage systems, and soil siltation are among the issues associated with fly ash disposal (3). Morupule Power Station produces an average of 240t/day of coal fly ash (4). This study reports synthesis and characterization of high purity silica nanoparticles from CFA, adsorption of Methylene Blue from water and modelling.

MATERIALS AND METHODS

Coal Fly Ash (from Morupule Power Plant, Botswana), Na₂CO₃, HCl, Methylene Blue. Silica nanoparticles were synthesized as shown in the schematic below FIG 1.



RESULTS

Characterization of Silica Nanoparticles: XRD, SEM, FTIR, BET

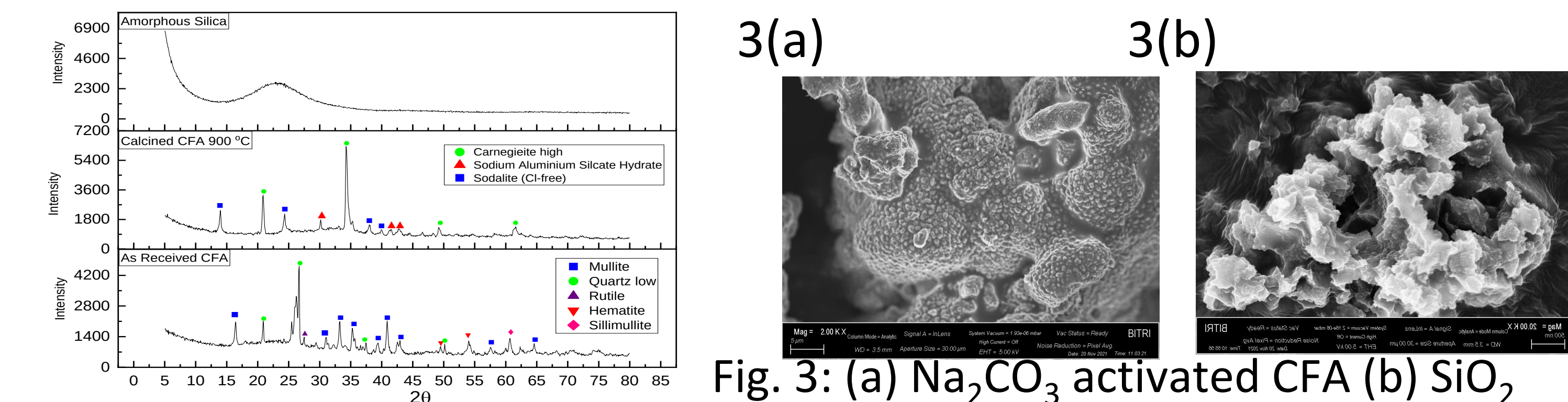


Fig. 2: As Received CFA, Calcined CFA and SiO₂ (99.1% XRF)

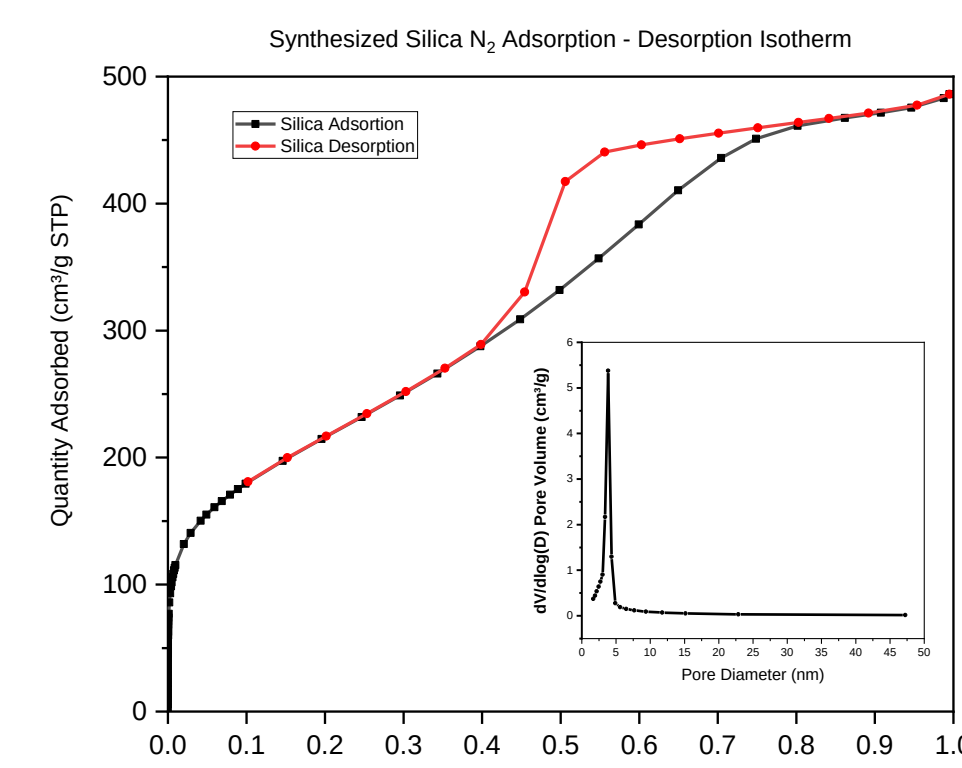


Fig. 4: SiO₂ BET plot

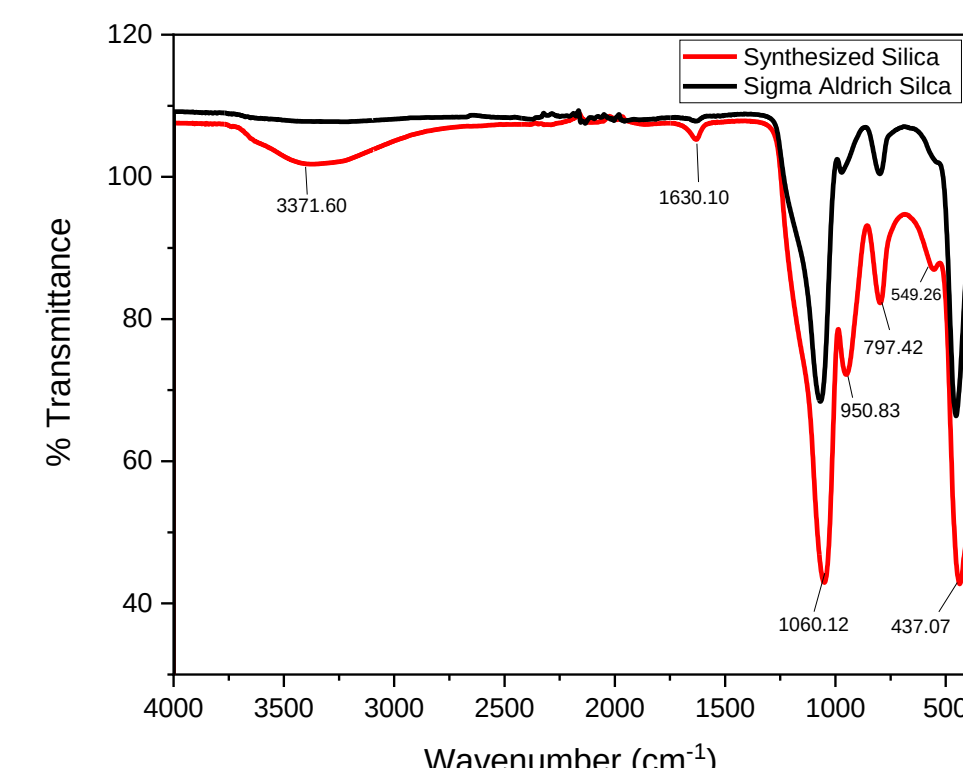


Fig. 5: SiO₂ FTIR plot

Methylene Blue Adsorption Studies

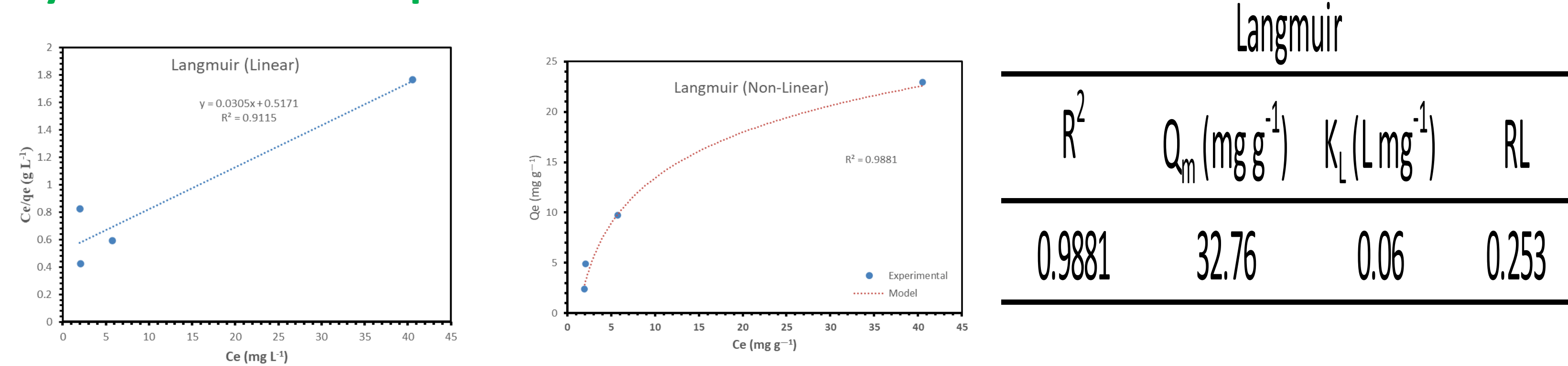


Fig. 6: Langmuir Isotherms (Linear and Non-Linear)

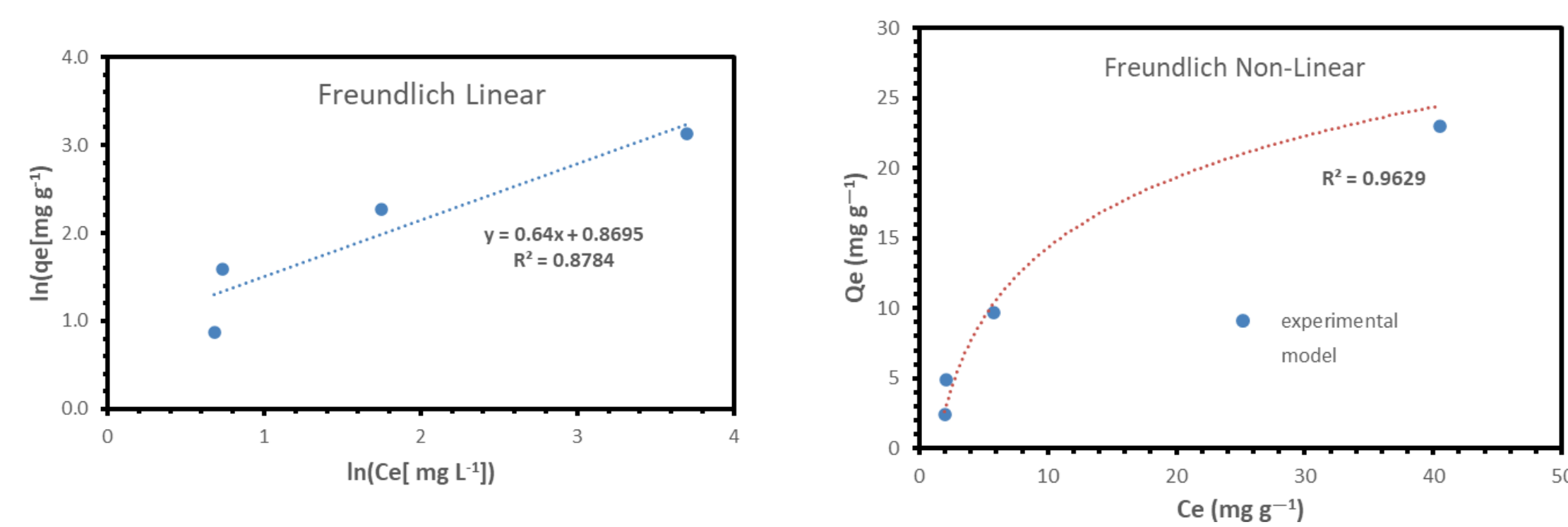


Fig. 8: Freundlich Isotherms (Linear and Non-Linear)

RESULTS CONTINUED, KINETICS

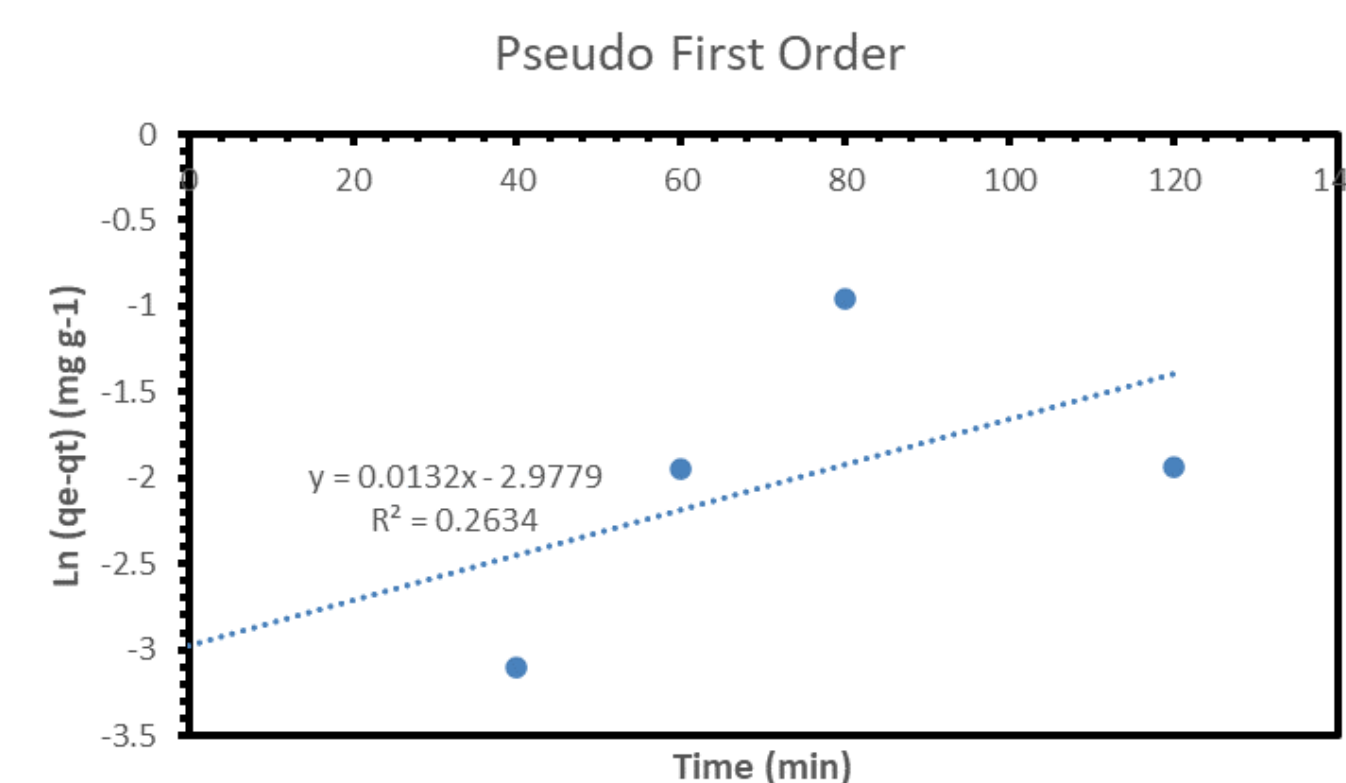


Fig. 9: Pseudo First Order (PFO)

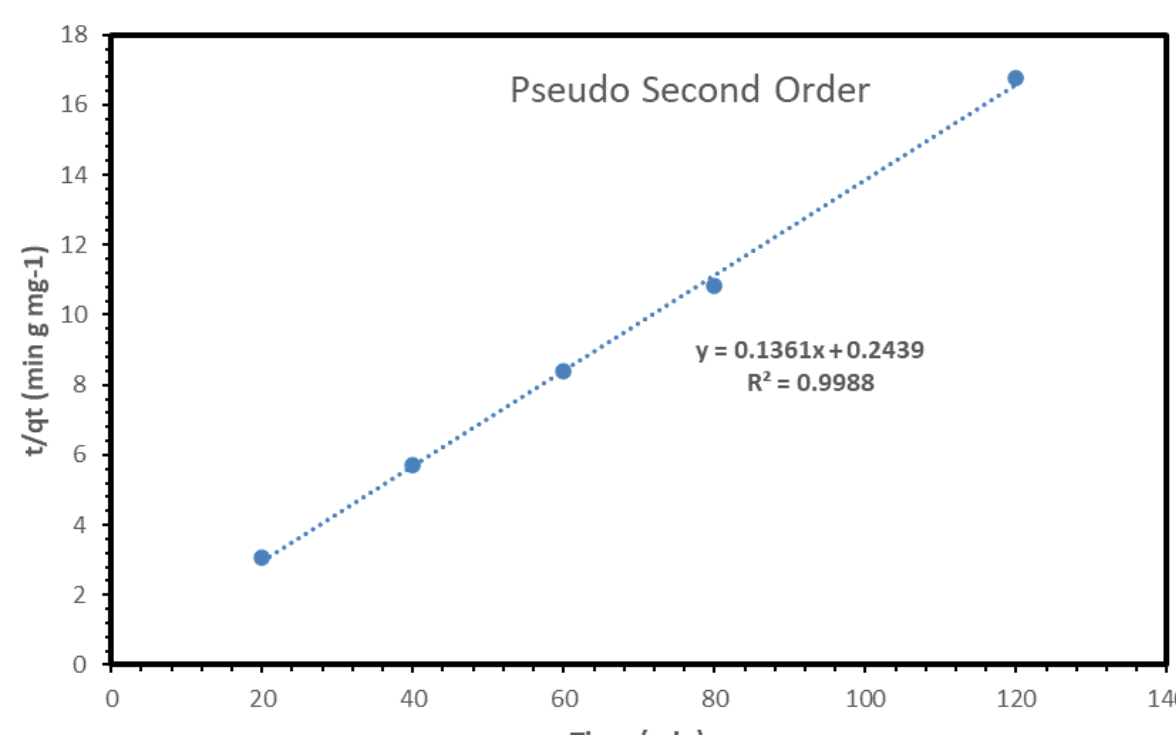


Fig. 10: Pseudo Second Order (PSO)

Pseudo First Order Model			Pseudo Second Order Model		
qe(mg g ⁻¹)	K ₁ (min ⁻¹)	R ²	qe(mg g ⁻¹)	K ₂ (g mg ⁻¹ min ⁻¹)	R ²
0.001052204	0.03	0.2634	7.35	0.076	0.9988

CONCLUSION

This study provided a sustainable process and low-cost method for the synthesis of high-grade mesoporous silica nanoparticles from the recycled Morupule A Power Station. As received CFA has 41.76 %SiO₂. High purity, 99.1% silica obtained after acid leaching with 793.51 m²/g BET surface area. Absorption of MB was optimum at pH 7, 3.1g dosage, 50 minutes and 150ppm MB with 99.9% removal. Lowest removal of 24.6% at pH 3, 0.1 g dosage, 90 minutes and 50ppm. Adsorption model is via Pseudo second order (R² > 0.99)

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