Facile synthesis of mesoporous silica nanoparticles and its electrochemical conversion of CO_2 to fuels

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ABSTRACT

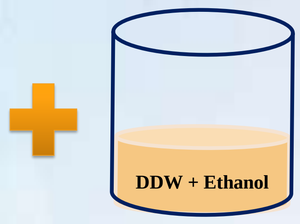
The increasing amount of CO_2 emissions from the industries is proving to have disastrous consequences on the environment. It would be highly beneficial if this CO_2 is to be recycled and converted into useful fuel. The aim of this project involves synthesizing a suitable catalyst which can be used for the electrochemical (EC) conversion of CO_2 to fuel. The developed catalyst should be mesoporous silica nanoparticles and loaded on to a metal oxide surface. The synthesis involved a relatively simple procedure of forming a homogenous mixture for the nanoparticles, drying the mixture for 2 days then loading on to the metal nitrate. Finally, multiple scans and tests were run on the synthesized sample to characterize its qualities. The results show that the synthesized mesoporous silica nanoparticles have suitable catalytic properties for electrochemical reduction of CO_2 to fuel.

INTRODUCTION

- Mesoporous materials have a high surface area and a narrow pore size. Mesoporous silica has a honey-comb structure which allows for a greater surface area of adsorption in catalysis.
- The need for an efficient catalyst for the photoelectrochemical conversion of CO_2 is extremely dire to efficiently reduce the emissions of CO_2 in the industry.
- The mesoporous silica nanoparticles can be coated with metal nitrates or metal oxides to enhance the catalytic properties. These metal oxides usually consist of particles less than 100nm in size and are widely used for catalytic applications.

METHODOLOGY

Dissolve Cetyl Trimethyl Ammonium Bromide (CTAB) in double distilled water and ethanol

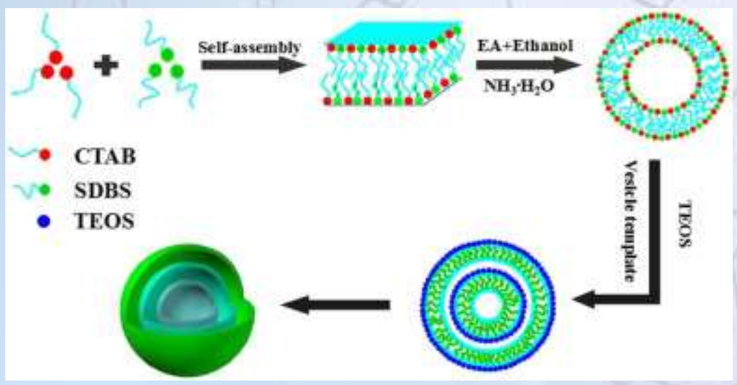


Thorough stirring and sonication for 1 hr

Add 8 mL Ammonia dropwise + 6mL TEOS dropwise

Stir the solution for 4 hrs

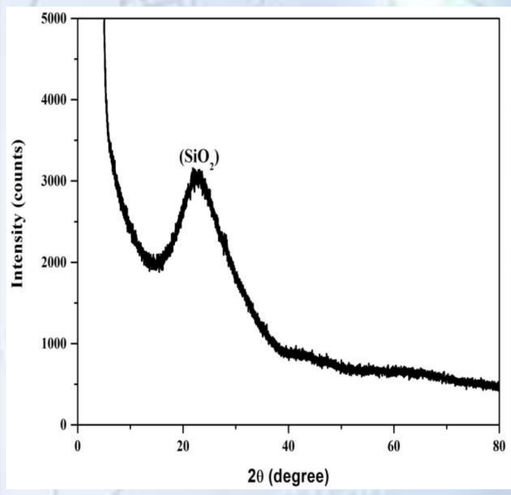
Appearance of final solution



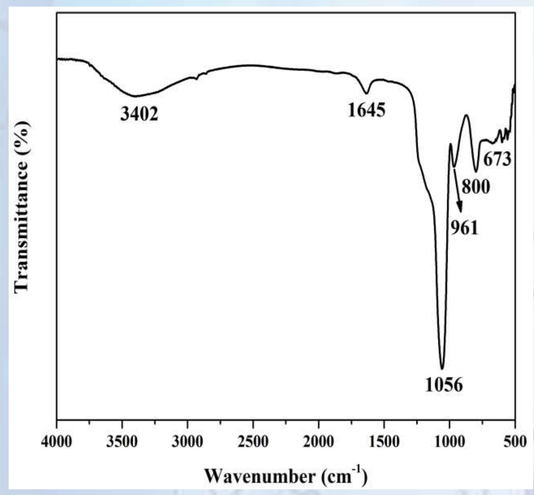
- ✓ The solution was dried at 120° C
- ✓ The powder was then grinded
- ✓ Finally, the sample was calcinated at 550° C for 5 hrs.

RESULTS & DISCUSSION

Structural Studies

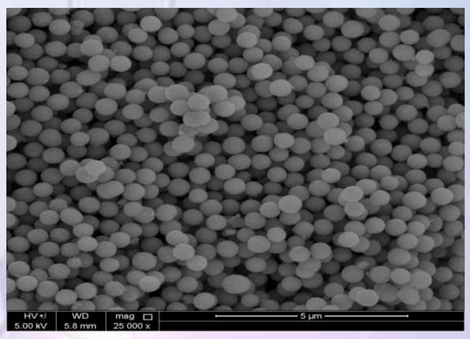


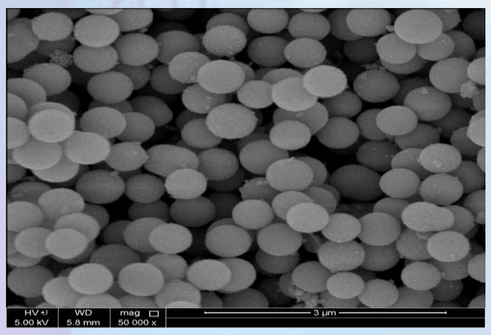
Results from X-Ray Diffraction showing the presence of Silica Dioxide at 22.07 degrees

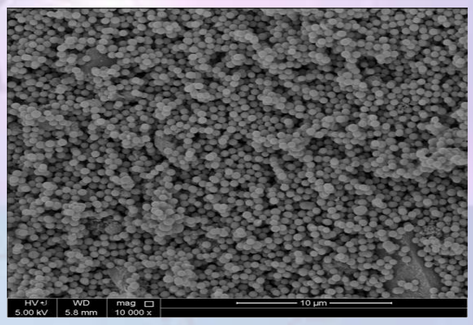


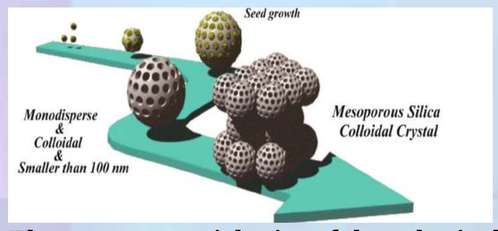
FTIR Spectrum of Mesoporous Silica Nanoparticles

Morphological Studies



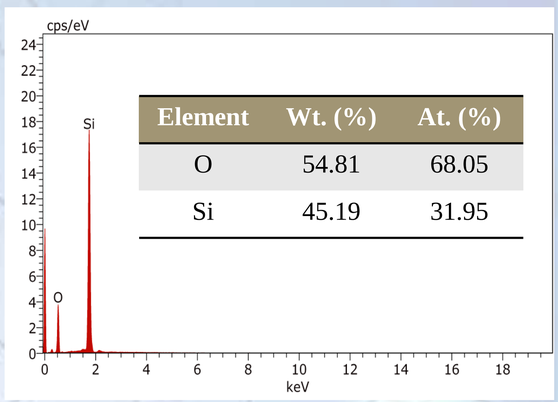






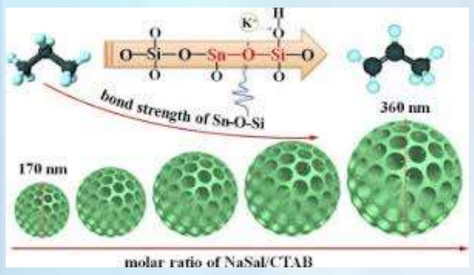
The average particle size of the spherical shape; the range of 80-100 nm. The mesoporous particle size was <40 nm

Scanning Electron Microscopy results showing the mesoporous silica nanoparticles

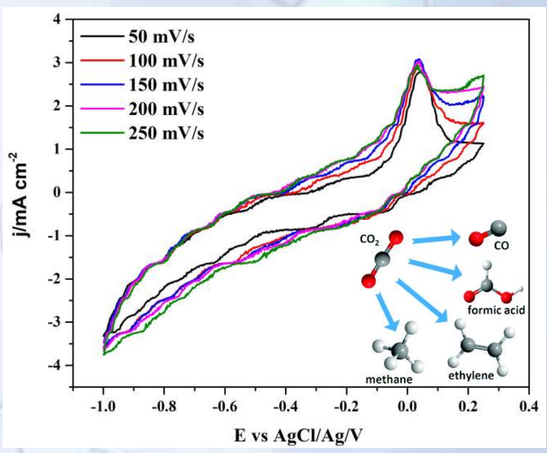


Element	Wt. (%)	At. (%)
O	54.81	68.05
Si	45.19	31.95

EDAX results showing the presence of only silicon and oxide, thus proving the purity of the synthesized sample.



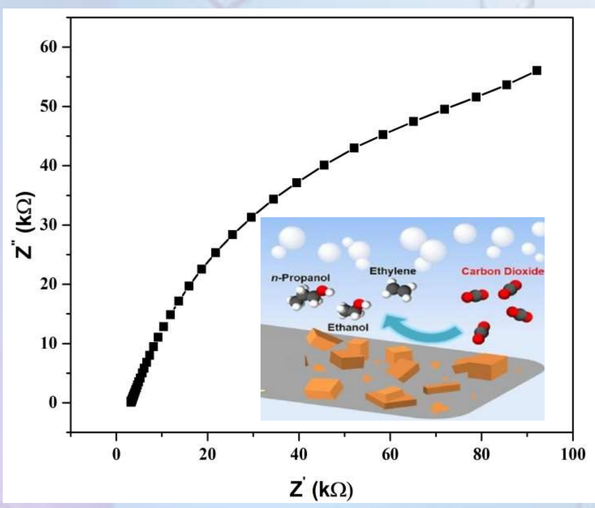
Electrochemical properties

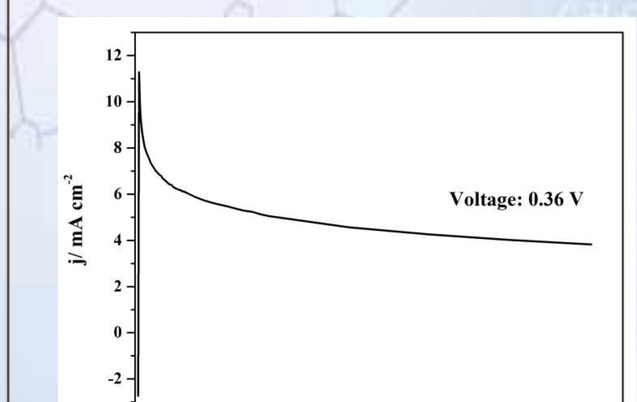


- **CV Studies of Mesoporous Silica nanoparticles in a CO_2 saturated aqua solution of 0.5 M NaOH at different scan rates**

Scan Rate	Current Density (mA/cm^2)
50	3.297
100	3.47
150	3.576
200	3.619
250	3.725

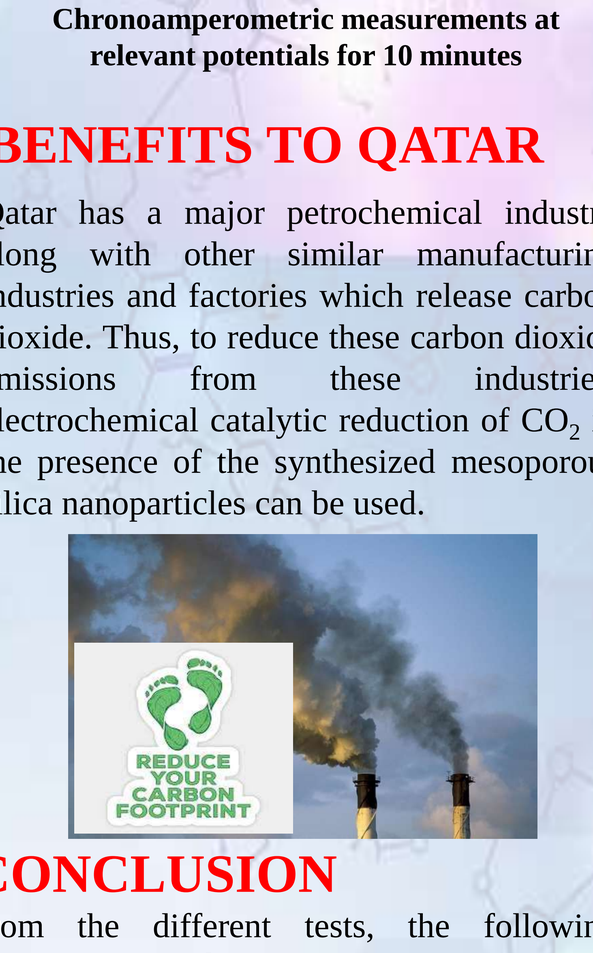
- **EIS studies of prepared mesoporous silica nanoparticles in the presence of CO_2 measured in 0.5 M NaOH under an applied potential of 0.2 V at room temperature.**
- **The charge transfer property of mesoporous silica nanoparticles – outstanding performance through EIS measurements.**





Current density against the square root of the scan rate

The slope of mesoporous silica nanoparticles is 0.04372 mV dec^{-1} obtained from the Randles-Seveik equation



Chronoamperometric measurements at relevant potentials for 10 minutes

BENEFITS TO QATAR

Qatar has a major petrochemical industry along with other similar manufacturing industries and factories which release carbon dioxide. Thus, to reduce these carbon dioxide emissions from these industries, electrochemical catalytic reduction of CO_2 in the presence of the synthesized mesoporous silica nanoparticles can be used.

CONCLUSION

From the different tests, the following properties were shown;
XRD: Mesoporous silica nanoparticles- crystalline periodic system
FTIR: 1056,800, 673 cm^{-1} (Si-O-Si stretching)
SEM with EDAX: Formation of mesoporous silica nanoparticles.
Thus, it can be stated that the synthesized mesoporous silica nanoparticles in this research are an appropriate material for electrocatalytic reduction of CO_2 to fuel.

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