VIETNAM NATIONAL UNIVERSITY - HCMC
HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY

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DISSERTATION INFORMATION

Title: S***ynthesis of aerogel and carbon aerogel materials from biomass for applications in insulation, adsorption, and energy storage***

Major: **Chemical Engineering** Major code: **9520301**

PhD candidate: **Dang Thanh Phong**

Advisors: **1: Assoc. Prof. Dr. Nguyen Huu Hieu**

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Major Contributions of This Dissertation:

In this dissertation, two simple synthesis processes for aerogel and carbon aerogel materials, which limit the use of chemicals, have been developed, complete with detailed parameters at each stage. The results of the thermal insulation study provide a clearer understanding of the insulation mechanism of aerogels synthesized from biomass. Through the results of the adsorption capability survey (cooking oil, diesel oil), a suitable biomass source was identified for synthesizing aerogels with high oil adsorption capacity. Additionally, the adsorption kinetics and mechanisms (cooking oil, diesel oil) were investigated to further describe the oil adsorption process of the material. Moreover, the successful surface modification of the material has opened up new research directions, offering more diverse and efficient oil adsorption solutions. The results also show that the aerogel material is easily recoverable and has high reusability, forming the basis for scaling up its application in industry.

Furthermore, the study of the electrochemical properties of the carbon aerogel (CA) material contributed to identifying suitable biomass and cross-linking agents for synthesizing CA for energy storage applications. The experimental design results for energy storage lay a scientific foundation that helps save time and costs for future research on the application of carbon aerogels in energy storage.

Based on the dissertation's findings, an aerogel material was developed from coconut coir, with a mass ratio of coconut cellulose (X-Cel) to the cross-linking agent mixture sodium alginate/zinc acetate of 10:1 (X-Cel:SAZ = 10:1). This material exhibited good compressive strength (Young's modulus 4.26 MPa), specific surface area of 1.43 m^2/g, pore volume of 0.004 cm^3/g, pore size of 23.71 Å, density of 0.075 g/cm^3, and porosity of 95%. The thermal conductivity of this material in the range of 47–50°C was 0.061–0.064 W/m·K, categorizing it as a material with relatively low thermal conductivity according to the TCVN 7194:2002 standard. The oil adsorption survey showed that the material's adsorption mechanism followed a pseudo-second-order kinetic model, and a correlation equation was identified between the material's density and its cooking oil and diesel oil adsorption capacities. Additionally, the aerogel material was successfully modified with stearic acid, resulting in a 25% and 14% increase in adsorption capacity for cooking oil and diesel oil, respectively. The recovery efficiency of the material reached over 75%, with a reuse efficiency of over 50% after ten cycles.

Based on the dissertation's results, a carbon aerogel material from coconut coir with a mass ratio of X-Cel:SAZ = 10:1 was developed for energy storage applications. The synthesized carbon aerogel had a specific surface area of 357.78 m^2/g, pore volume of 0.202 cm^3/g, pore size of 16.2 Å, density of 0.087 g/cm^3, porosity of 95%, and a composition consisting mainly of carbon (approximately 85% by weight), with an I_D/I_G ratio of 1.03. The electrochemical property survey showed that the SAZX-CA10 material had a maximum specific capacitance of 496.3 F/g at a scan rate of 5 mV/s within a voltage range of –1.0 to 0.0 V in 0.94 M PBS electrolyte, and maintained 78% of its energy storage capacity after 2000 charge-discharge cycles at a current density of 15 A/g.

Through the findings of the dissertation, both biomass sources were shown to be suitable for synthesizing aerogel and carbon aerogel materials with sodium alginate/zinc acetate cross-linking for applications in insulation, adsorption, and energy storage. However, coconut coir proved to be more suitable than corn stalk. The aerogel material demonstrated thermal insulation and adsorption performance comparable to those in previous studies. At the same time, the obtained carbon aerogel material showed good energy storage performance, classifying it among the high-capacitance materials derived from biomass.

Advisors		**Ph.D. candidate**
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