

Studi Sintesis $[\text{Cu}_3(\text{C}_6\text{H}_3(\text{COO})_3)_2(\text{H}_2\text{O})_3]_n$ (HKUST-1) menggunakan Metode Solvotermal pada Variasi Fraksi Volume Pelarut *N,N*-Dimethylformamide sebagai Material Prekursor Sensor Gas

Oleh
Muhammad Fu'ad Saifuddin
15/379887/TK/43152

Diajukan kepada Departemen Teknik Nuklir dan Teknik Fisika Fakultas Teknik
Universitas Gadjah Mada pada tanggal 20 Juli 2020
untuk memenuhi sebagian persyaratan untuk memperoleh derajat
Sarjana Program Studi Teknik Fisika

INTISARI

Teknologi sensor gas belakangan ini banyak mendapatkan perhatian mengingat perannya yang luas dalam berbagai bidang. Pengembangan sensor gas telah banyak dilakukan, salah satunya dari segi material yang digunakan. Material $[\text{Cu}_3(\text{C}_6\text{H}_3(\text{COO})_3)_2(\text{H}_2\text{O})_3]_n$ atau HKUST-1 merupakan salah satu jenis material *Metal-Organic Frameworks* yang telah banyak diteliti sebagai material sensor gas. Karakteristik porositas material HKUST-1 sangat mempengaruhi kinerjanya sebagai sensor gas. Penggunaan pelarut *N,N*-dimethylformamide dalam sintesis solvotermal HKUST-1 telah banyak dilakukan. Jumlah *N,N*-dimethylformamide terbukti mempengaruhi jumlah produk HKUST-1 yang dihasilkan. Oleh karena itu perlu dilakukan penelitian yang berkaitan dengan jumlah pelarut *N,N*-dimethylformamide terhadap karakteristik porositas HKUST-1.

Metode sintesis HKUST-1 yang digunakan dalam penelitian ini adalah metode solvotermal. Analisis terhadap karakteristik HKUST-1 yang disintesis pada tiga variasi fraksi volume *N,N*-dimethylformamide dalam pelarut sintesis dilakukan dengan uji *X ray diffraction* (XRD), uji *scanning electron microscope* (SEM), dan uji adsorpsi isothermal nitrogen. Untuk menentukan pengaruh fraksi volume *N,N*-dimethylformamide dalam pelarut terhadap karakteristik HKUST-1 dilakukan uji statistik dengan uji normalitas Shapiro-Wilk dan uji korelasi Pearson pada tingkat kepercayaan 95%.

Hasil uji XRD dan SEM menunjukkan bahwa ketiga sampel memiliki kristal berbentuk oktahedral atau menyerupai oktahedral, dengan sudut sisi tajam, tanpa adanya pengotor CuO dan Cu₂O. Perubahan fraksi volume *N,N*-dimethylformamide tidak mempengaruhi morfologi kristal dan pola XRD sampel yang dihasilkan. Hasil uji adsorpsi isothermal nitrogen menunjukkan bahwa fraksi volume *N,N*-dimethylformamide juga tidak mempengaruhi luas permukaan BET dan volume pori kumulatif sampel. Tetapi fraksi volume *N,N*-dimethylformamide dalam pelarut sintesis terbukti mempengaruhi massa produk dan ukuran diameter pori sampel. Semakin besar fraksi volume *N,N*-dimethylformamide dalam pelarut sintesis dapat meningkatkan massa produk dan memperkecil ukuran diameter pori HKUST-1 yang dihasilkan. Penggunaan fraksi volume *N,N*-dimethylformamide sebesar 0,444 menghasilkan sampel yang memiliki karakteristik paling baik dengan

rerata massa produk 2,43 gram, luas permukaan BET 1450 m²/g dan volume pori kumulatif 0,5829 mL/g.

Kata kunci: *Metal-Organic Frameworks* HKUST-1, sintesis solvothermal, DMF, pola XRD, karakteristik porositas.

Pembimbing Utama : Ferdiansjah, ST., M.Eng.Sc.

Pembimbing Pendamping : Ir. Anung Muharini, M.T.

Synthesis Study of $[\text{Cu}_3(\text{C}_6\text{H}_3(\text{COO})_3)_2(\text{H}_2\text{O})_3]_n$ (HKUST-1) using the Solvothermal Method on Variations of N, N-Dimethylformamide Solvent Volume Fraction as a Gas Sensor Precursor Material

by
Muhammad Fu'ad Saifuddin
15/379887/TK/43152

Submitted to the Departement of Nuclear Engineering and Engineering Physics
Faculty of Engineering Universitas Gadjah Mada on July 20, 2020
in partial fulfillment of the requirement for the Degree of
Bachelor of Engineering in Engineering Physics.

ABSTRACT

Recently, gas sensor technology has received much attention, given its broad role in various fields. The development of gas sensors has been carried out, one of them in terms of the material used. Material $[\text{Cu}_3(\text{C}_6\text{H}_3(\text{COO})_3)_2(\text{H}_2\text{O})_3]_n$ or HKUST-1 is one type of Metal-Organic Framework material that has been widely studied as a gas sensor material. The porosity characteristics of HKUST-1 material significantly affect its performance as a gas sensor. The use of N, N-dimethylformamide solvent in HKUST-1 solvothermal synthesis is widely used. The amount of N, N-dimethylformamide has been shown to affect the amount of HKUST-1 produced. Therefore research related to the amount of N, N-dimethylformamide solvent on the porosity characteristics of HKUST-1 was conducted.

The synthesis method used in this research was the solvothermal method. Analysis of the HKUST-1 characteristics synthesized in three variations of the N, N-dimethylformamide volume fraction in the synthesis solvent was carried out by X-ray diffraction (XRD), scanning electron microscope (SEM) and nitrogen isothermal adsorption tests. To determine the effect of the volume fraction of N, N-dimethylformamide in solvents on the characteristics of HKUST-1, statistical tests were performed by the Shapiro-Wilk normality test and the Pearson correlation tests at a 95% confidence level.

The test result of XRD and SEM showed that all three samples had octahedral or similar octahedral crystals, with sharp side angles, without CuO and Cu₂O impurities. Changes in the volume fraction of N, N-dimethylformamide did not affect the morphology of the crystals and the XRD patterns of the resulting samples. The results of isothermal nitrogen adsorption tests showed that the volume fraction of N, N-dimethylformamide also did not affect the BET surface area and cumulative pore volume of the sample. However, the volume fraction of N, N-dimethylformamide in the synthesis solvent, had been shown to influence the sample product mass and pore diameter. The higher the volume fraction of N, N-dimethylformamide in the synthesis solvent increased the mass of the product and reduced the pore diameter of HKUST-1 produced. The usage of N, N-dimethylformamide volume fraction of 0.444 produced the best characteristics with

a product mass average of 2.43 grams, BET surface area of $1450 \text{ m}^2/\text{g}$, a cumulative pore volume of 0.5829 mL/g .

Keywords: Metal-Organic Frameworks HKUST-1, solvothermal synthesis, DMF, XRD pattern, porosity characteristic.

Supervisor : Ferdiansjah, ST., M.Eng.Sc.

Co-supervisor : Ir. Anung Muharini, M.T.