Jour. Myan. Acad. Arts & Sc. 2005 **Vol. III. No. 1 Chemistry**

Unburned Carbon from Samlaung Coal as Environmental Friendly Sorbent Material

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Abstract

The increasing role of coal as a source of energy in the 21st century will demand environmental and cost-effective strategies for the use of carbonaceous waste products from coal combustion. The carbonaceous in fly ash, unburned carbon (UC), is a potential precursor for the production of adsorbent carbons, since it has gone through a devolatization process while in the combustion, and therefore, only requires to be activated. This paper demonstrates the potential for converting UC from Samlaung coal to activated carbons. After heat activation at 970°C, the UC sample was generated to activated carbons having microporous structure.

This study concerns with adsorption behavior (decolourization and metal uptake) of UC from Samlaung coal. Batch tests and column tests were carried out. Adsorption isotherms has been obtained from these tests. Results show that the UC have equal or better adsorption capacity comparing with other activated carbons. It was found that heat treatment of Samlaung coal in the presence of air at 970°C enhanced the adsorption capacity.

Keyword: unburned carbon (UC), Samlaung coal, decolourization, metal uptake, adsorption isotherm

Introduction

The increasing role of coal as a source of energy in the 21st century will demand environmental and cost effective strategies for the use of carbonaceous waste products from coal combustion. The carbonaceous residue in the fly ash, unburned carbon (UC), is a potential precursor for the production of adsorbent carbons, since it has gone through a devolatilization process while in the combustor, and therefore, only requires to be activated.

The electric power industry relies heavily on the use of coal as the primary energy source. Furthermore, coal is the most abundant fossil energy source in the 21st century. However, the use of coal for energy generation

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forces environmental challenges due to the emission of pollutants such as NOx and SOx from coal combustion furnaces and such pressures will only intensify in the next century. To gurantee a key role of coal as energy source, the conventional processes for coal utilization have to be redesigned to comply with clean air regulation. In particular, the implementation of these regulations concerning NOx emission is being addressed in coal combustion furnaces mainly by a combination of low NOx burners and catalytic reduction systems. Although low-NOx burner technologies efficiently decrease the emission level by lowering the temperature of combustion, they also reduce the combustion efficiency resulting in an increase in carbonaceous waste product.

The carbonaceous residue in fly ash, unburned carbon, is a potential precursor for the production of adsorbent carbons, since it has gone through a devolatilization process while in the combustor, and therefore, only requires to be activated. The ubiquitous use of activated carbons as adsorbent materials in a broad range of increasing household, medical, industrial, military and scientific applications. These range from gas phase adsorption in household air-conditioning equipment and industrial emission control, to liquid-phase adsorption for water treatment and gold recovery. Due to the expanding market for activated carbons, especially in application related to environmental protection such as air and water purification, new precursors are being sought. The unburned carbon in the ash furnishes satisfactorily all these conditions. Therefore, the use of unburned carbons as precursor for the production of activated carbons would help the utilities to offset the cost of installing and running a beneficiation process.

In Myanmar, unburned carbons can be obtained from electric power plant, cement industry, coal fuel train and other purposes. Nowadays, the unburned carbons are produced from electric power plant at Teegyit (Southern Shan State).

In this research program, samples from Samlaung coal mine was collected and they were treated by means of heat to produce the unburned carbons as activated carbons. The sorptive properties of samples was investigated based on Langmuir isotherms. Moreover, metal-uptake properties of samples was determined fundamentally on the break-through (column method) as well as batch methods. All the studies were shown by comparing with commercial activated carbons.

Experimental

Materials and Methods

Chemicals

The chemicals used in the research were from British Drug House chemical limited, Poole, England; " E. MERCK, Darmstadt; Germany, St.Louis, USA". The chemicals had been used as it was received unless otherwise stated.

Apparatus

Apart from the glassware, labware and other supporting equipments, the specific apparatus used in these experiments are follows.

Balance - Type H6T dig.cap.160g.No.280764, E.Mettler, Switzerland

Furnace - An automatic high temperature box furnace, Muffle furnace

X-Ray Diffraction (XRD Regaku, D-Max 2200, Japan)

UV-visible Spectrometer - Shimadzu, Japan(UV-vis 190-700 nm)(±.001A)(± 1nm)

FT-IR Spectrometer - Model Genesis II , Australia

SEM - Fine coat, Ion sputter JFC-1100, JEOL Ltd. Tokyo, Japan

pH meter - Model- 3071, Jenway, UK

Mechanical Shaker - SBS30 , Bibby Sterilin Limited, UK

Sieve - British Standard Sieve (Gallenkamp of different mesh size No.80-200)

Column (1.3cm x 30cm)

Stopped Watch

Pyrex Glassware

Tested Organism (Received and worked out at Bacteriology Department, DMR)

Escherichia coli (ETEC)

Escherichia coli (EPEC)

Vibrio fluvialis

Vibrio cholerae

Activation of Samlaung Coal

Activation Process

The activated carbons (unburned carbons) was obtained after heating at 970°C for period of 60 minutes in an autoclave furnace.

Characterization of Unburned Carbons (UC)

The activated carbons (UC) were characterized by XRD, FT-IR techniques according to ASTM Standard.

Adsorption Studies of UC and Commercial Activated Carbons (CAC)

Decolourization Test

Unburned Carbons (UC) and Commercial Activated Carbons (CAC) were tested with methylene blue (0.1%) solution by carbon dosage method.

Metal-Uptake Test (Batch and Column Test)

Unburned Carbons (UC) and Commercial Activated Carbons (CAC) were tested with 0.1M $CuSO_4.5H_2O$ solution by both batch and column test (break-through methods).

Antibacterial Activity Test of Cu^{++} Loaded UC vs CAC

Each coal sample such as unburned carbon (UC) and commercial activated carbon (CAC) from each column break-through experiment was treated with four types of bacteria; (1)Escherichia coli (ETEC), (2)Escherichia coli (EPEC), (3)Vibrio fluvialis, (4)Vibrio cholerae by Agar Disc Diffusion method.

Results and Discussion

Color Removal Properties of UC VS CAC

Figure.1. shows the adsorption isotherm of UC sample from Samlaung coal and illustrates the decolourizaion properties of this material with methylene blue (0.1%) solution. From the determination of slope value C/x/m vs C plots, monolayer coverage value 43.47 mg g^{-1} was calculated. Commercial activated carbons can decolourize completely 0.1% methylene blue solution. From the results UC shows quite comparable adsorptive nature to CAC for decolorization.

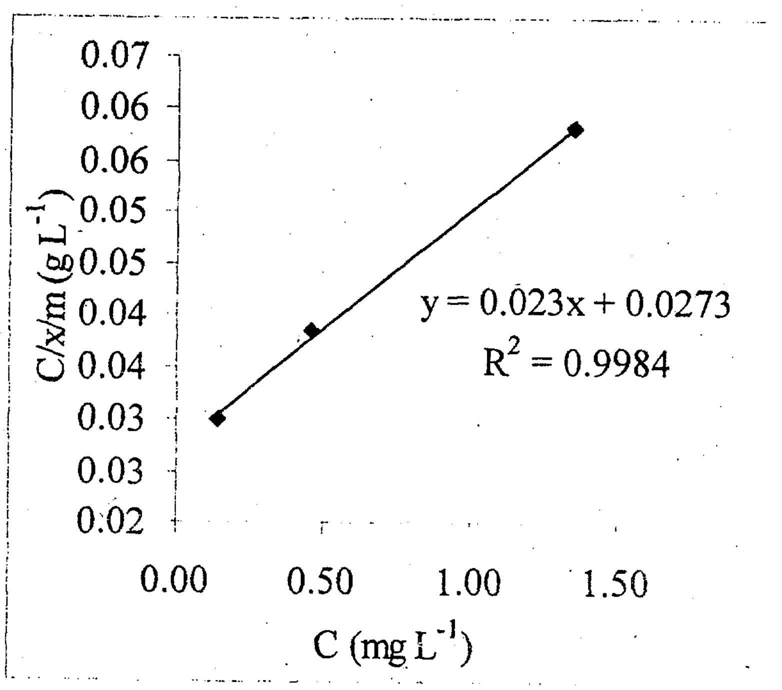


Figure.1. Langmuir Isotherm for UC with methylene blue (0.1%) solution

Metal Loading Character of UC VS CAC (Cu^{++})

Figure. 2. and Figure.3. show the adsorption studies of UC and CAC with Cu^{2+} by means of batch test. From these isotherms, UC sample displays linearity and monolayer coverage value 0.0475 mg g^{-1} but CAC isotherm gives random manner. Therefore, UC sample favours the adsorption power of Cu^{2+} much more than the CAC sample.

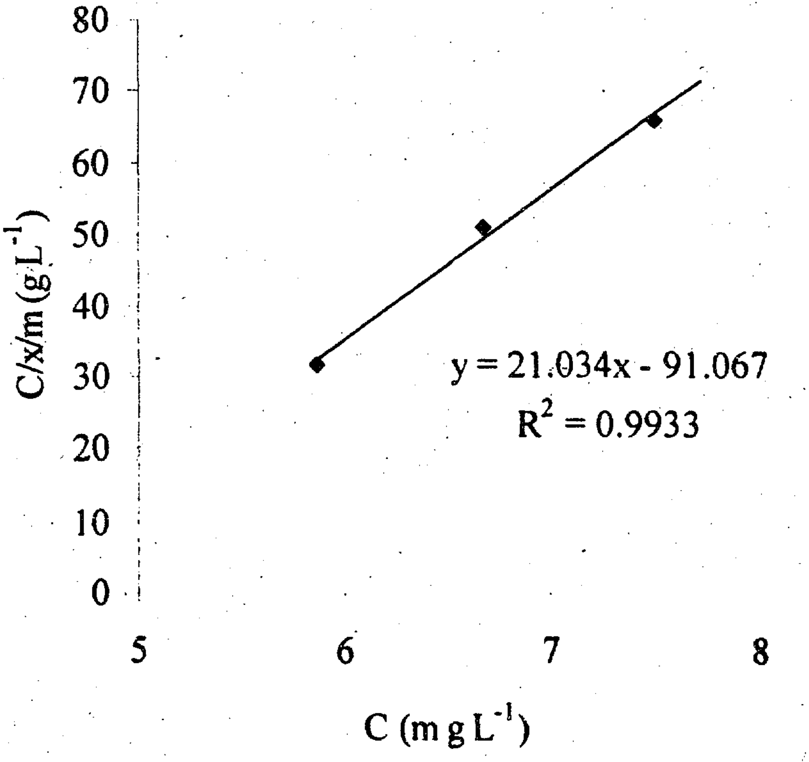


Figure.2. Langmuir Isotherm for adsorption study of Cu^{++} on UC

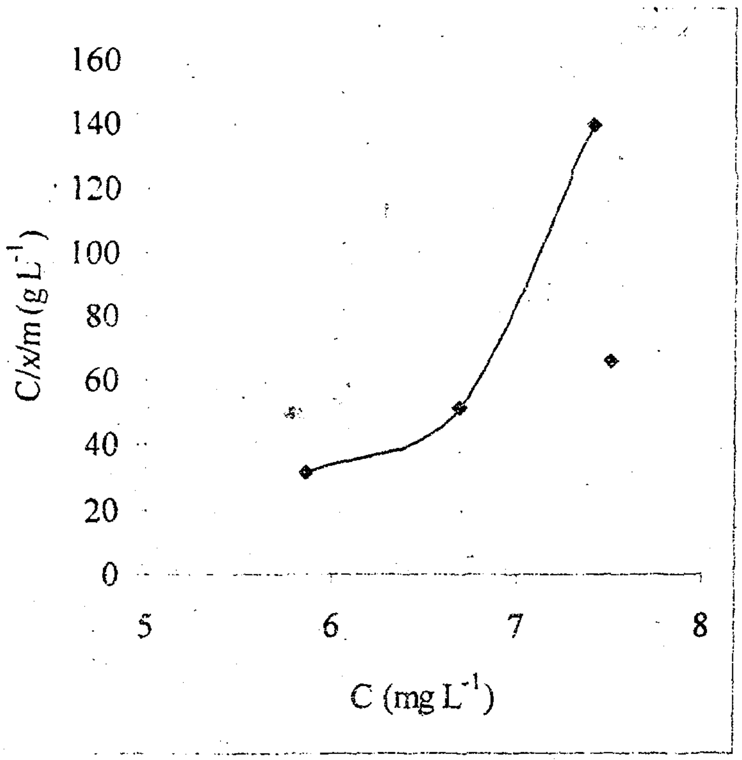


Figure.3. Langmuir Isotherm for adsorption study of Cu^{2+} on CAC

Figure.4 and Figure.5 show break-through curve for adsorption of Cu^{2+} with UC and CAC samples by column test. From the calculation for break-through capacity of adsorption of Cu^{2+}, UC samples gives 95.31mg of Cu^{2+} for 1g of loaded UC sample. Consequently, CAC indicates 63.54mg of Cu^{2+} for 1g of loaded CAC sample. It can be assumed that the nature of sorption goes by two different mechanisms. The sorption with UC may be due to the ion exchange predominating the sorption process and that on CAC, the sorption is due to Langmuir sorption process only. If multiplayer loading has taken place the profile will be in the cascading nature. In the Figure.5 after 30 ml volume full fraction the loading on CAC may have undergone some desorption process.

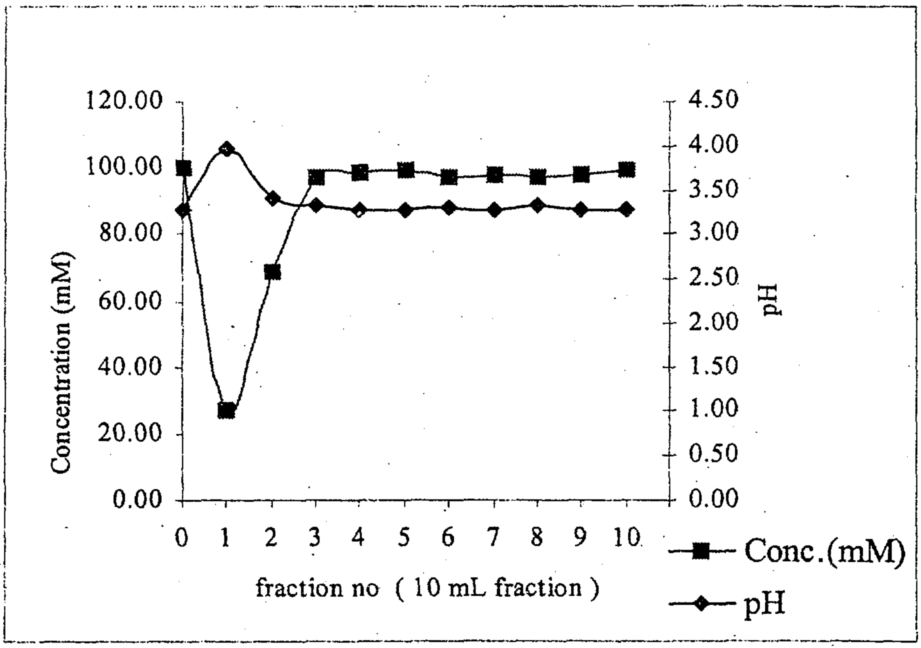


Figure4. Break-through curve for adsorption of Cu^{2+}: as it enters a packed column of UC (2g) with a flow rate of 20mL/hr at 32±2 °C (pH profile vs volume fractions)

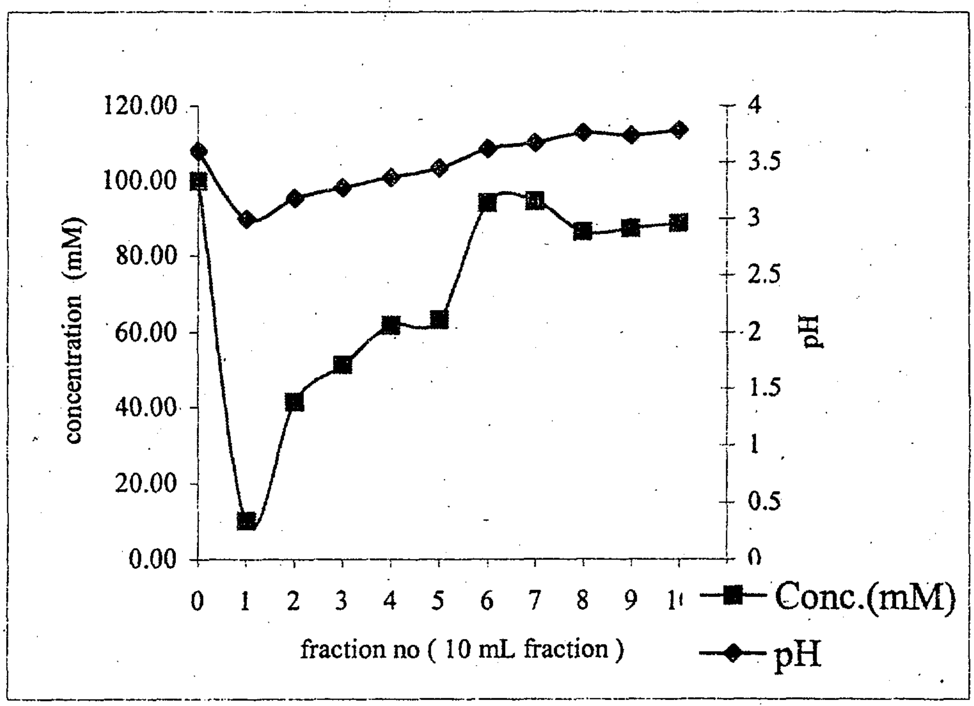


Figure.5. Break-through curve for adsorption of Cu^{2+}: as it enters a packed column of CAC (2g) with a flow rate of 20mL/hr at 32±2 °C(pH profile vs volume fractions)

Comparative Study of Antibacterial Activities of Cu^{2+} Loaded UC vs CAC

From the results of antibacterial test, it was found that UC showed more bioactivity to bacterial (A) and (C) than CAC and that confirms the presence of Cu^{2+} on the surfaces of UC after column break-through experiment. (See Figure 6. and 7)

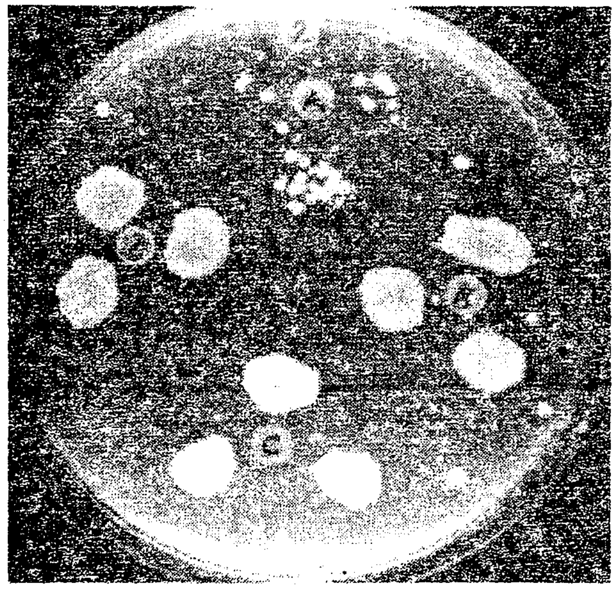


Figure 6. Agar disc diffusion test for CAC

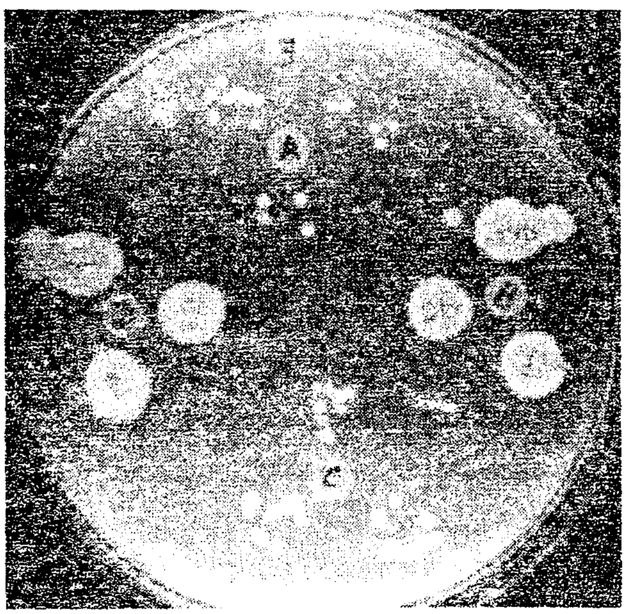
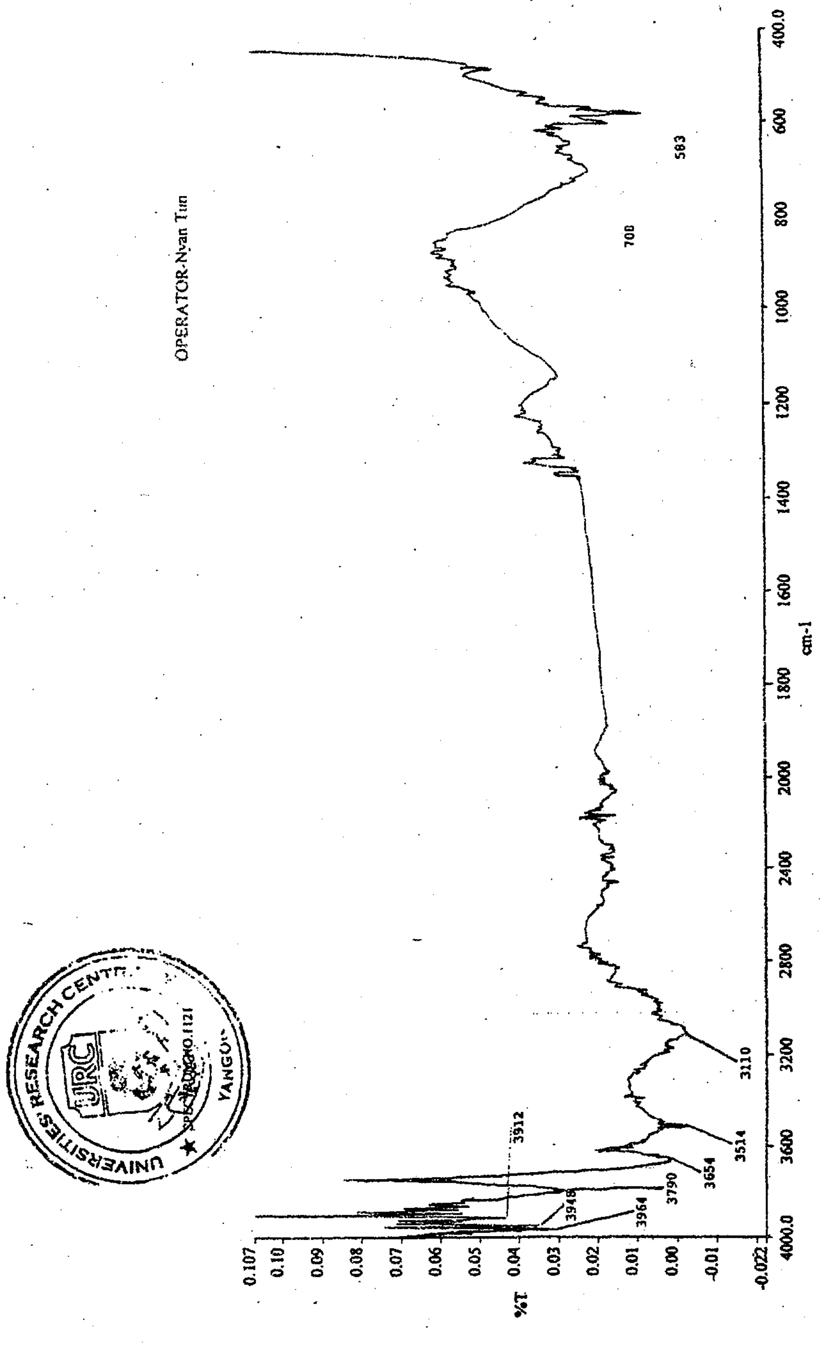


Figure7. Agar disc diffusion test for Cu^{2+} loaded UC

Conclusion

The sorbent nature of unburned carbon (UC) with commercial activated carbon (CAC) has been studied with decolourization, loading of Cu^{2+} ion and antibacterial activity tests and from the results it shows that unburned carbon can be used as environmental friendly sorbent material for multi-purposes.



SAMPLE NO.ZN-SUC

Figure A. FT-IR Spectrum of UC Before Cu^{++} Loading

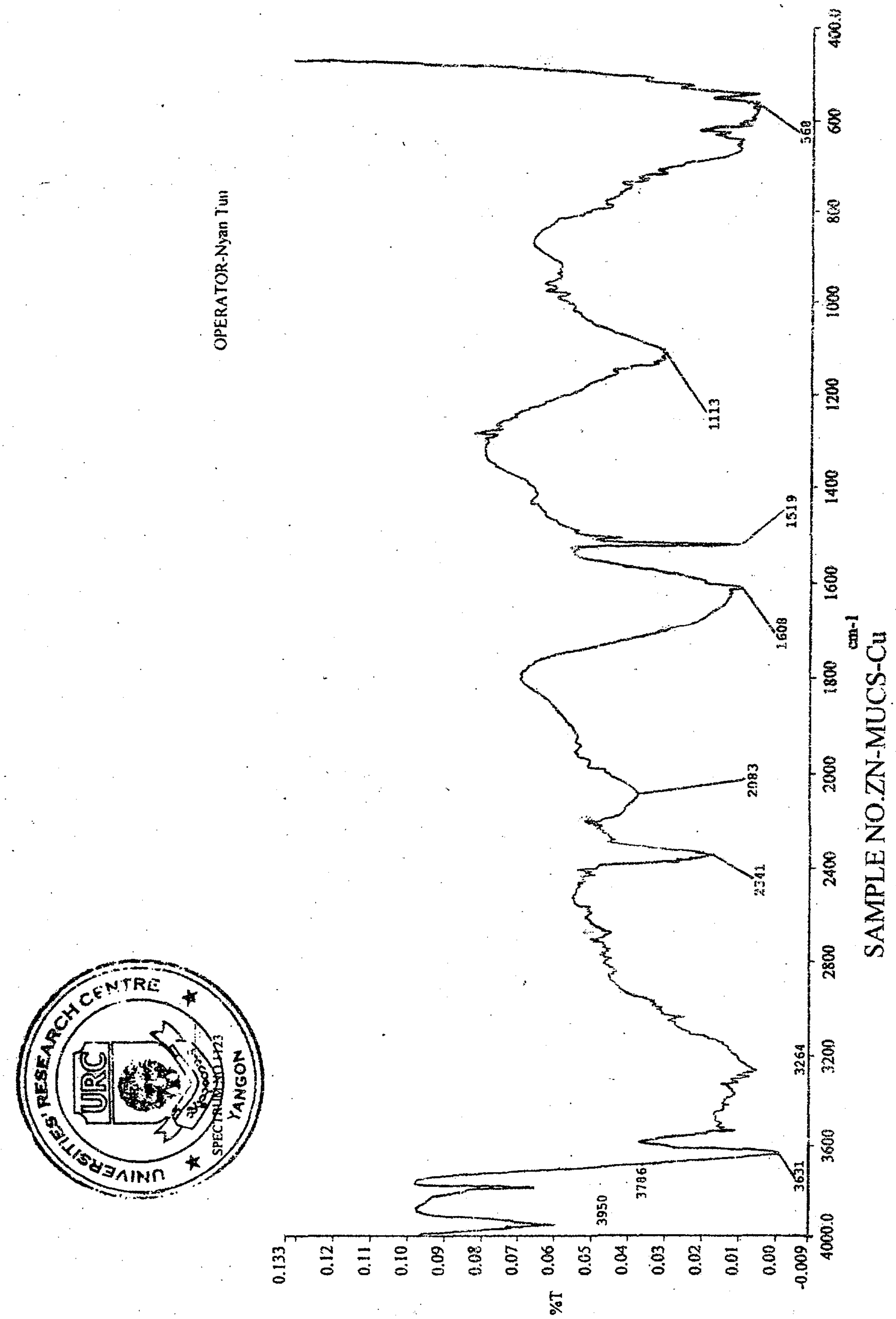


Figure B. FT-IR Spectrum of UC After Cu^{++} Loading

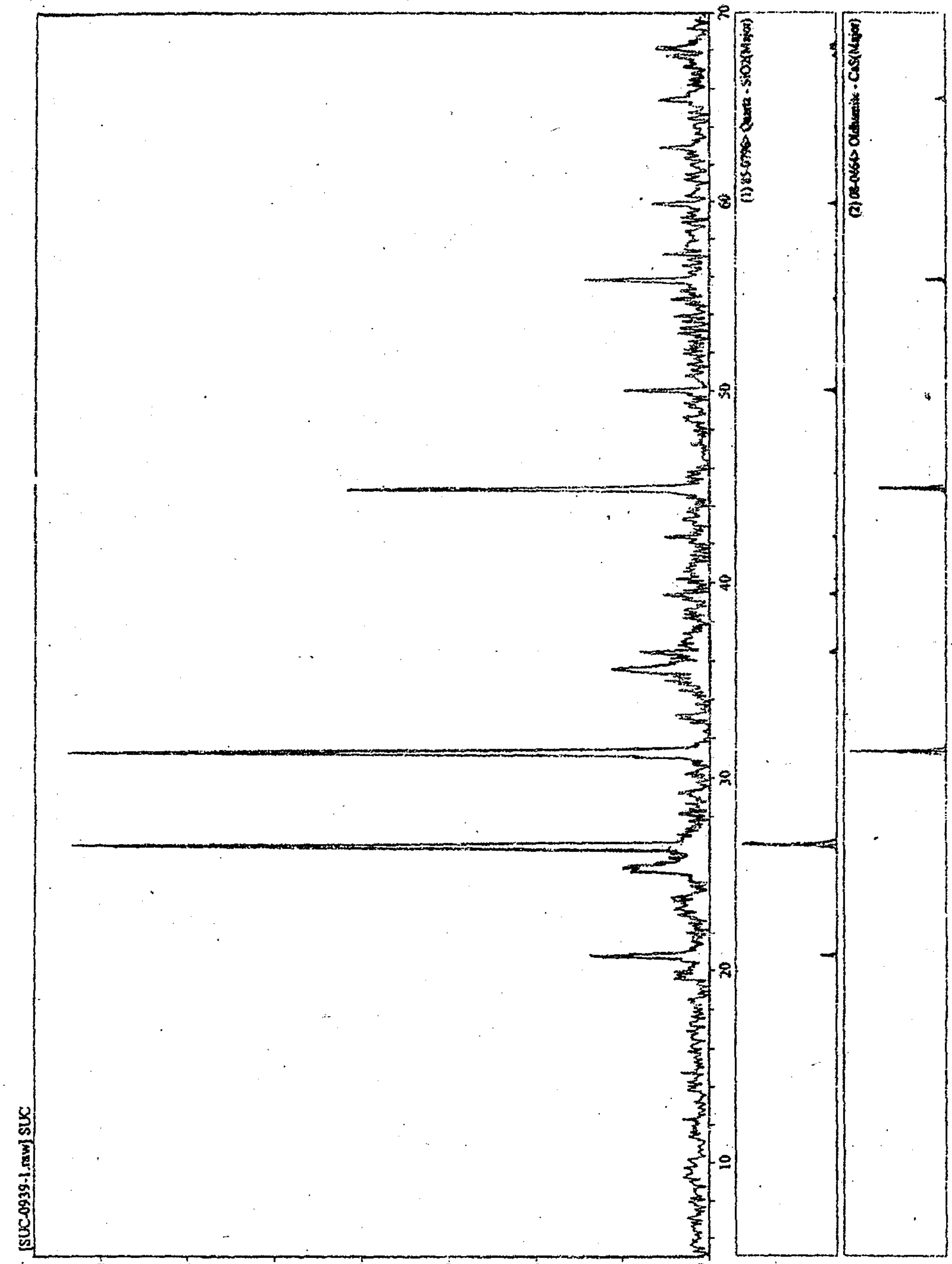


Figure C. XRD Spectrum of UC Before Cu^{++} Loading

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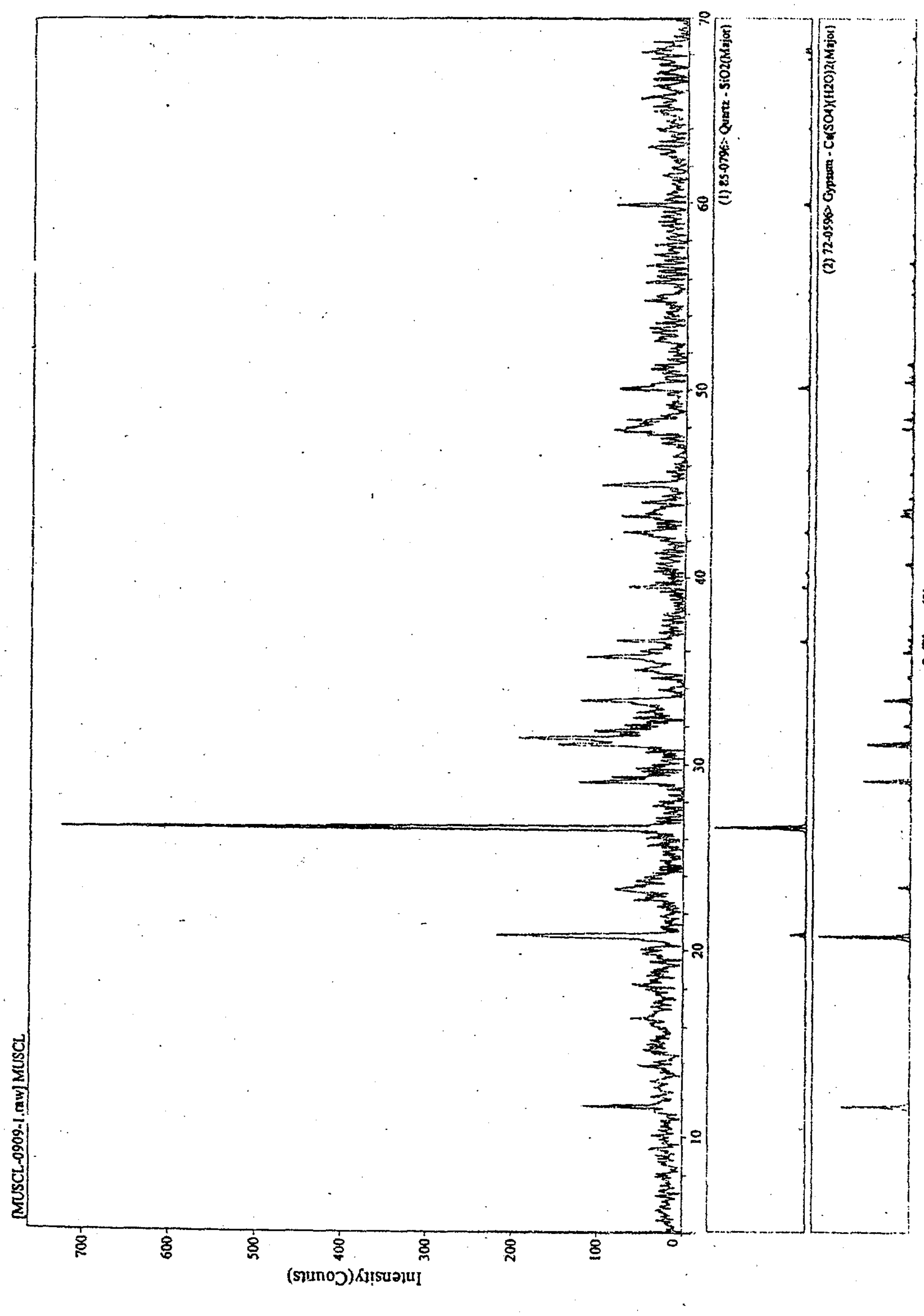

Figure C. XRD Spectrum of UC After Cu^{++} Loading

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