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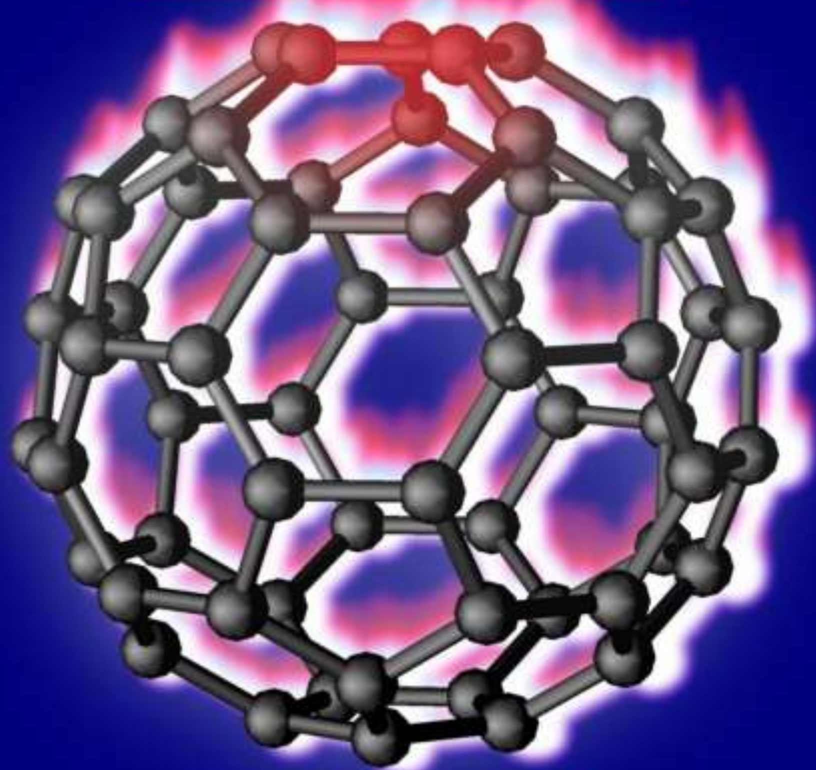
The Physics and Chemistry of Carbon and Nanoenergetic Materials



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Chapter 2

ORAL PRESENTATIONS
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Session 1 - Carbon Materials and their Application

TABLE of CONTENTS

RICE HUSK-DERIVED POROUS CARBON WITH FEW-LAYER GRAPHENE FOR SYMMETRIC ELECTRIC DOUBLE-LAYER SUPERCAPACITOR ELECTRODES

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It was shown that carbon materials derived from waste vegetable are the most attractive electrode materials for supercapacitors, which is due to their relatively low cost, high surface area and its availability [1-4]. In the process of synthesis we used the rice husk as the carbon source. Rice is a grain widely consumed by a large part of the world's human population, especially in Asian countries. A protective outer layer of grain, which is commonly known as rice husk, is produced as a by-product from rice mills. World rice production in 2017/18 is expected to decrease only slightly compared to the previous year and the amount will be 487.2 million metric tons. Each ton of produced rice produces about 0.2 tons of rice husks, suggesting that annually produces about 97 million tons of rice husk. Rice husks have very low commercial value and causes environmental problems associated with its disposal. Therefore, the conversion and use of rice husk in useful materials is necessary to solve the existing environmental problem and waste management, which in turn contributes to economic success for rice-producing countries.

Activated carbon with few-layer graphene was synthesized using rice husk as the starting material and potassium hydroxide (KOH) as the activation agent. This methodology demonstrates the utility of rice husk as a carbon source and stainless steel double walled reactor as a protective barrier against oxidation of parent carbon source and KOH mixture. Oxidation may occur during the synthesis process due to high-temperature annealing. Influence of activation temperature, amount of activating agent and pre-grinding of raw vegetable waste on the porosity and formation of new crystallized phase in resulting carbons have been investigated. The yield of carbonized rice husk by using RH as starting material was ~ 44% by weight. The yield of activated carbon by using carbonized rice husk was ~ 10% by weight. The weight loss is attributed to the removal of silica and other impurities in the RH, as well as the removal of disordered carbon. To identify surface morphological features of graphene layers we have used scanning electron microscopy SEM. Studies were conducted on the electron microscope Jeol JSM-6490LA. The graphene layers have a complex structure, however, they exhibit a characteristic macrostructure and texture of the surface. Raman spectroscopy was analyzed using a 473 nm wavelength excitation at 6-7 points of the sample. As can be seen from the spectra, the resulting carbon material consists of anisotropic disordered carbon structures and a significant amount of few-layer graphene structures. Spectral analysis of graphene obtained from RH showed: the intensity of the peaks G and 2D indicates that the graphene film consists of three or more layers (I_{2D}/I_G= 0.63). All spectra contain D and 2D peaks, indicating the presence of deformations in the crystal structure of the graphene film, as well as mechanical stresses which can also be seen in the SEM microphotographs. These peaks are well known to be characteristic for graphene, furthermore the intensity ratio between peak *G* (I_G) and peak *2D* (I_{2D}) can be used to estimate the number of graphene layers [5,6]. It can be stated with the Raman spectra in Figure 1 that few layer graphene is present in the activated rice husk samples.

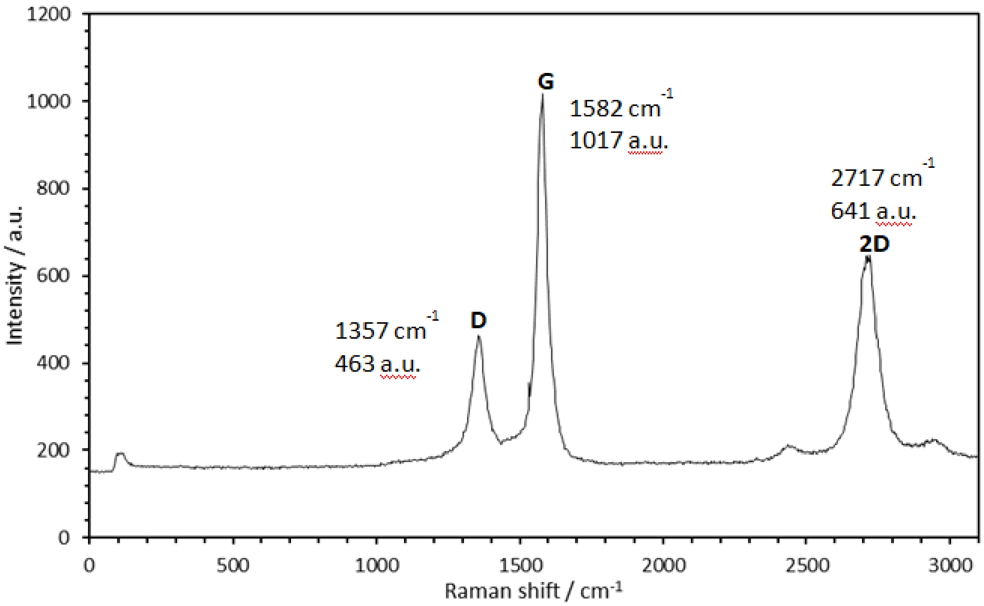

Figure 1 Raman spectra of ARH, showing the three significant peaks (*D*, *G*, *2D*) for the presence and evaluation of graphene layers

The obtained activated carbon with graphitized structure was applied as electrode active materials for symmetric electric double-layer supercapacitor electrodes. Electrochemical characterization of resulting carbons was performed by cyclic voltammetry, galvanostatic charge-discharging, and electrochemical impedance spectroscopy. The specific capacitance values were up to 223 F/g for a scan rate of 10 mV/s in 6 mol/l potassium hydroxide electrolyte, which is higher than most of commercially available activated carbons tested under similar conditions.

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