Evaluation of EVA foam wastes from solar panel manufacturing processes in energy storage application

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Introduction: Industrialisation is one of the key elements that has had the greatest impact on human life over the last two centuries. Modernisation, the ability to produce various products cheaper through mass production, the creation of many new jobs and fields of employment, technological developments in all areas of daily life such as health, education, entertainment, transport, and communication are among the positive aspects of industrialisation in a global sense. Moreover, improvements in the quality of life following the industrial revolution, advances in medical knowledge and research, easier access to food as a result of innovations in agriculture and the widespread access to public services as a result of urbanisation have all contributed to the rapid increase in average human life expectancy. On the other hand, industrial wastes may cause serious damage to the environment. They also have negative effects in terms of energy, cost and environment during their disposal and management. Instead of simply disposing of industrial wastes, extracting valuable chemicals, or converting them into value-added materials is key to achieving sustainability. Several studies have been conducted to evaluate industrial wastes (Wu et al. 2020, Mukherjee et al. 2021, Liu et al. 2022).

This study aims to produce activated carbon samples by using EVA foam wastes from industrial solar panel manufacturing process and use them in energy storage application as electrode materials.

Material and methods: EVA foams were obtained from Kalyon Photovoltaic Solar Technologies Factory. Phosphoric acid (H_3PO_4, Merck) and potassium hydroxide (KOH, Merck) were used as activating chemicals. Waste EVA foams were cut into small pieces before being interacted with H_3PO_4 and KOH. Waste EVA foams and activating chemicals were mixed at different weight ratios (1:1, 1:2, 1:3) to investigate the effects of activation chemical on surface characteristics of activated carbon. A precarbonisation process was applied by microwave heating (30 s) for H_3PO_4 activation (activation temperature was 450 °C). On the other hand, the mixtures were precarbonised at 400 °C, 500 °C and 600 °C and activated at 800 °C for KOH activation. The activated carbon samples were washed with hot distilled water to remove impurities and reach neutral pH value. Finally, they were dried in an oven at 105 °C.

The energy storage performances of activated carbon samples were examined in supercapacitor application. BET surface area and pore size distribution analyses were conducted to determine structural properties. Chemical structures of the samples were investigated by FTIR analysis. Electrochemical performances were determined by two-electrode configuration using a potentiostat/galvanostat device. Stainless steel electrodes (1 cm x 1 cm) were used as current collector. Activated carbon, carbon black and polyvinylidene fluoride were mixed at a weight ratio of 85:10:5 in n-methyl pyrrolidone, respectively. The prepared mixture was sprayed to the current collector. The current collectors were vacuum dried at 80 °C and then sealed with parafilm to obtain supercapacitor. Cyclic voltammetry, galvanostatic charge discharge and electrochemical impedance spectroscopy measurement were applied to test the energy storage performances of the samples. 1 M H_2SO_4 and 6 M KOH were used as electrolyte in the cells. The potential windows were 0 – 0.8 V and 0 – 1 V, respectively.

Results and discussion: In preliminary experiments, only one activated carbon sample was prepared. The waste EVA foams precarbonised at 600 °C for 1 h and then carbonised/activated at 800 °C in N_2 atmosphere (1h). The production and characterization of other samples will be completed soon.

Figure 1 shows the BET surface area and pore size distribution of activated carbon samples (EVA-AC600800). It is clear from the Figure 1a that the isotherms are Type IV isotherms according to IUPAC classification. The hysteresis loop shows the existence of mesopores in the structure. The rapid increase at low P/Po values indicates microporous structure as well. Both of micropore and mesopore distribution can be seen in Figure 1b. Table 1 gives the BET surface area and pore fractions of the samples. The samples had a BET surface area of 487 m^2/g and a total pore volume of 0.6981 cm^3/g. It was determined that the samples had a mesopore dominant structure. The mesopore fraction was 82.64 %.

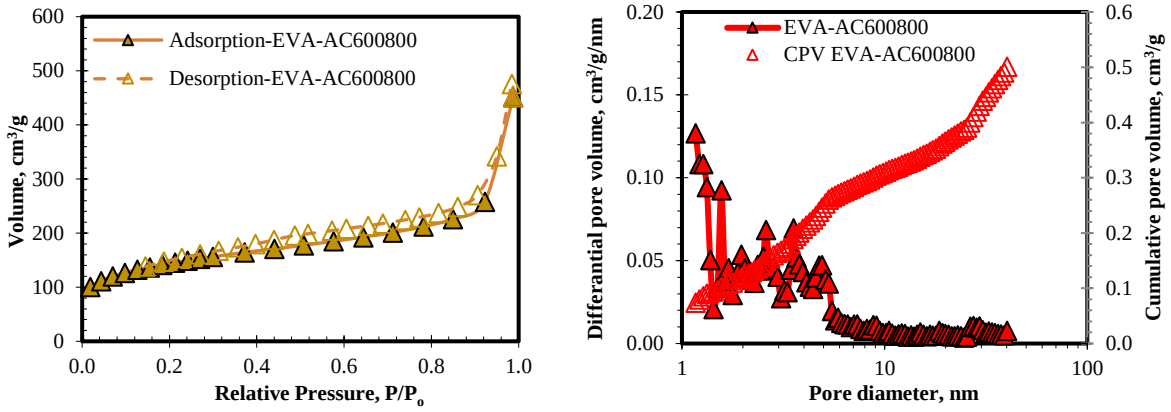

Figure 1. a) N_2 adsorption-desorption isotherms and b) cumulative pore volume and pore size distribution of EVA foam derived activated carbon samples.

Table 1. BET surface area and pore fractions of activated carbon samples.

BET surface area, m^2/g	V_{micro}, cm^3/g	V_{meso}, cm^3/g	V_{total}, cm^3/g	% V_{micro}	% V_{meso}
487	0.1212	0.5769	0.6981	17.36	82.64

Conclusions: The porous structure is an important feature for activated carbons so that they can be used in energy storage applications. The easy penetration of electrolyte ions through the pores positively affects the electrochemical performance. According to pore size distribution, it can be said that activated carbon samples have sufficient porosity below 10 nm which represents suitable adsorption sites for electrolyte ions. In the next phase of the study, new activated carbon samples will be produced by applying different activation chemicals and pre-carbonisation temperatures. The effects of the type and the amount of activation chemical on the surface and electrochemical properties will be evaluated.

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