

Polymer Composite Framework for Trapping of Polysulfide Formation in Li-S Batteries

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ABSTRACT

In this manuscript the utilization of polymeric materials as trapping agent for better electrochemical performance of lithium sulfur (Li-S) batteries has been examined. These batteries have created colossal enthusiasm as a cutting edge battery research and energy densities which significantly surpass Li-ion battery innovations. The key role of polymer as trapping agent in Li-S battery was introduced and composed regarding to trap the polysulfides formation which occurs during charging and discharging of Li-S batteries. Profoundly cross-linked polymer-electrolyte covering layers with electron-donating group were intended to tie the lithium polysulfides. Spectroscopic confirmations for the presence of lithium connections between the lithium polysulfides and the electron-donating groups will be introduced.

KEYWORDS: Polymer matrix, Trapping agent, Polysulfides, Li-S battery

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INTRODUCTION

With the advancement of the technology and the increase in the expectations of society energy demand is developing. In present situation, people are confronting a serious energy emergency. All the while, ecological contamination issues brought about by the inordinate utilization of assets are progressively genuine. In this way, the improvement of novel security naturally well-disposed and environmentally friendly power is must. The optional lithium battery which is another compact force gracefully has a wide application prospect in the change, transportation and storage of energy. The normal largescale dispersion of various type of electric vehicles has set off the quick improvement in energy storage frameworks supported by exceptional qualities [1]. Among numerous kinds of auxiliary lithium battery being explored, lithium-sulfur (Li-S) batteries have pulled in an ever increasing number of considerations because of many favourable points. Lithium sulfur battery is viewed as one of the most encouraging substance power sources due to its specific capacity (1675 mAh/g), energy density (2600 Wh/kg) theoretically are very high as compared to present lithium ion batteries [2-3]. Notwithstanding these focal points, lithium-sulfur batteries are confronting a few issues which direly should be illuminated prior to understanding their enormous scope applications. Most importantly, essential sulfur and its last decrease item Li_2S are covers which have poor conductive capacity for both electron and particle. Thus, the electrochemical redox response will be influenced. Moreover, the transitional polysulfides during the charge/discharge cycle of sulfur cathode are effortlessly broken down into fluid electrolyte, which will prompt the loss of dynamic materials and the diminishing of limit. Likewise, the broke down middle polysulfides will go through the

separator, move to the anode and respond with the lithium metal, and afterward move back to cathode. This process corresponds to shuttle effect, which will decay the electrochemical exhibition of lithium-sulfur battery [4-6]. Different procedures and techniques have been created to hinder these issues. Various carbon conductive materials mesoporous carbon, CNT's, porous carbon, graphene, carbon nanofibers, conductive polymers, were acquainted with improve the use of sulfur and abatement the disintegration conduct of middle of the road polysulfides partly [7]. Here we used sulphur as host material along with varying concentration of multi-walled carbon nanotubes and polystyrene to design a polymer composite framework as cathode material to bind polysulphide and to deliver better results. Polymer system because of its light weight, easy availability with minimum price and inertness (inertness of polymer can infiltrate and interlock the pores of sulfur have thus and moderately stable structure is acquired for electrode which conveys great electrochemical execution), it can serve as a trapper (here polystyrene shapes a defensive layer on the cathode to forestall the dissolving conduct of middle polysulfide into electrolyte during cycling) just as it can likewise give flexibility to terminal. In short we can say that polymer could act as a polysulfide scissor which could diminish the measure of long polysulfide chain in this way it likewise lessens polysulfide transport and facilitate the difficulties for commercialization of such requesting framework in future.

MATERIAL AND METHODS

Materials

Polystyrene granules was purchased from Gharda chemicals Gujarat, Sulfur powder 99% from Sigma Aldrich, MWCNT's was purchased from Chengdu institute of organic chemistry having diameter 10-20 nm and 10 micrometre length, Carbon disulphide pure was purchased from Merck, Silver paste was used for contact making using copper wire for measurement.

Characterisation

X-ray diffractometer (MO K α , $\lambda=1.5406 \text{ \AA}$) Bruker system in range $2\theta=20^\circ-80^\circ$ used for structural analysis, FT-IR (Bruker) in wavenumber range $500-4000 \text{ cm}^{-1}$ was used for bonding analysis have been used at room temperature in attenuated total reflectance mode using zinc selenide crystal having resolution 0.8 cm^{-1} , JEOL make JSM-7610FPlus FESEM ultra-high-resolution electron microscope used for surface analysis of film, Precision impedance analyzer (Wayne Kerr 6500B) in frequency range($100\text{Hz}-120\text{MHz}$) to determine dielectric constant.

RESULTS

Fig. 1(A) shows XRD plots of pristine sulfur, CNT and S/CNT/PS composite. Figure 1(A-a) shows that sulfur is in good agreement with standard pattern of sulfur (JCPDS card no 77-0145) having signature peak at $2\theta = 23^\circ$, relates to the Fddd orthorhombic structure of sulfur was detected in the final product. The XRD information don't show any new stages in the composite plot, which could be a sign of no side reaction during treatment.

Fig. 1(B) shows FT-IR spectra with transmittance characteristics bands for pristine polystyrene, sulfur, CNT, and composite material film. Pristine and composite material spectra exhibit almost similar characteristics confirms that composite making process has not

affected the host material bonding and properties. The peaks assigned at 680cm^{-1} , 1030cm^{-1} , 1437cm^{-1} , 2930 cm^{-1} corresponds to C-H, C-C, C=C, C-H bonds. Peaks at 690 cm^{-1} in pristine polystyrene gets shorter in composite spectra which is due to higher concentration of sulfur.

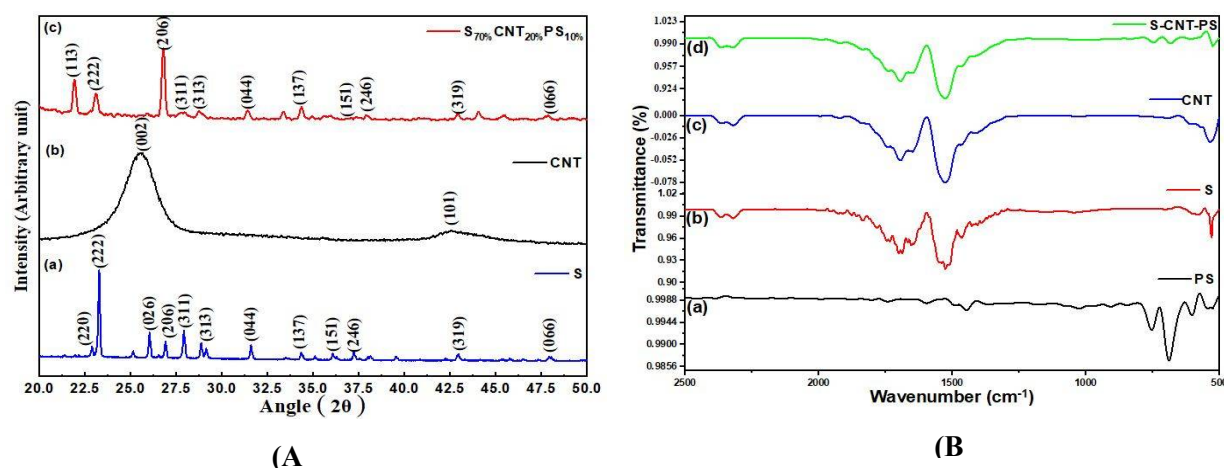


Figure 1. (A) XRD plots of (a) sulfur (b) CNT (c) Composite electrode material (B) FT-IR plots of (a) Polystyrene (b) Sulfur (c) carbon nanotube (d) Composite electrode material

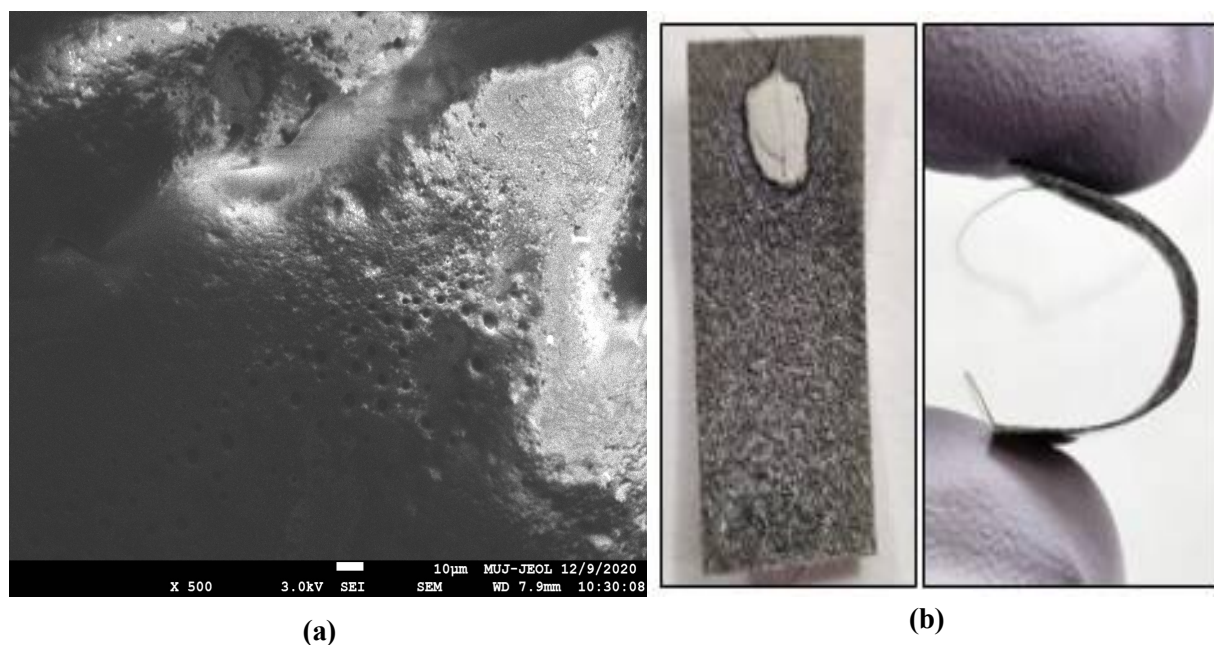


Figure 2. (a) FESEM image of composite electrode (b) Image of prepared flexible electrode

In order to identify about surface morphology surface FE-SEM image (figure 2(a)) of composite done that exhibits porous, shiny and bumpy surface without any agglomeration of material and no cracks were found on the surface. Porous nature of the surface helps to accommodate material on volume expansion during electrochemical testing. Figure 2(b) shows image of composite electrode prepared and its flexibility.

Dielectric constant of composite figure 3 was found to be increased with increase in concentration of CNT and reduction in polymer concentration at low frequency and reduces with higher freq. value. This is because of that at lower frequencies of applied voltage all free dipolar gatherings in the material can situate themselves bringing about higher dielectric constant (in short it could be because of space charge polarization emerging at limit interfaces) as recurrence of applied field builds the greater bipolar gatherings discover hard to arrange at similar spot as the rotating field so the commitment of these dipolar gatherings to dielectric constant continues diminishing.

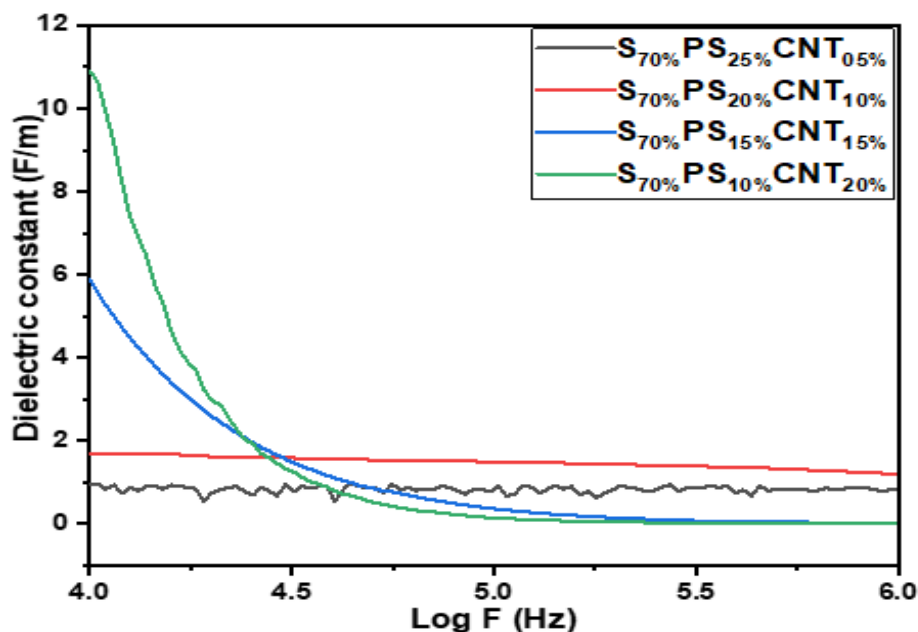


Figure 3. Dielectric plot for composite electrodes

CONCLUSIONS

FT-IR spectra confirms that composite making process has not affected the host material properties, surface SEM image of composite exhibit porous, shiny and bumpy surface without any agglomeration of material. Dielectric constant of composite was found to be increased with increase in concentration of CNT and reduction in polymer concentration at low frequency and reduces with higher freq. value. In short we can say that polymer could act as a polysulfide scissor which could reduce the amount of long polysulfide chain thereby it also reduces polysulfide shuttle and ease the challenges for commercialization of such demanding system in future.

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