Electronic Supplementary Material (ESI) for Nanoscale Advances.

Supporting Information

Iron-selenide based titanium dioxide nanocomposites as a novel electrode material for 2.3 V operating asymmetric supercapacitors

Muhammad Zia Ullah Shah[1,2] , Hongying Hou[1*], Muhammad Sajjad[3**], Muhammad Sanaullah Shah[1,2], Kashif Safeen[4], and A. Shah[2**]

[1]Faculty of Materials Science and Engineering, Kunming University of Science and Technology, Kunming 650093, China

[2]National Institute of Lasers and Optronics College, Pakistan Institute of Engineering and Applied Sciences, Nilore, Islamabad 45650, Pakistan

[3]College of Chemistry and Life Sciences, Zhejiang Normal University, Jinhua 321004, P. R China

[4]Department of Physics, Abdul Wali Khan University, Mardan 23200, KPK, Pakistan

* Corresponding author. Faculty of Materials Science and Engineering, Kunming University of Science and Technology, Kunming 650093, China

**Corresponding author.

E-mail address: sajjadfisica@gmail.com (M. Sajjad) hongyinghou@kust.edu.cn (H. Hou), attashah168@gmail.com (A. Shah)

1. Electrochemical measurement

The electrochemical measurements were studied using the Gamry workstation through a three-electrode setup with Ag/AgCl as a reference electrode, Pt as a counter electrode, and composites as a working electrode in 3M KOH electrolyte. The homogenous slurry was combined with the active ingredient, carbon black, and Nafion binder in an 8:1:1 mass ratio. The final product was pasted on Ni foam having an area of 2 × 3 cm and dried at 80 °C for 8 h. The mass loading of the active material was ~2 mg. The characteristics of electrodes for SCs were investigated using the following equations [44-46].

$$\frac{m_+}{m_-} = \frac{C_- \times V_-}{C_+ \times V_+} \tag{1}$$

$$C_S = \frac{I \times \Delta t}{m \times \Delta V} \tag{2}$$

$$E = \frac{C_S \times \Delta V^2}{7.2} \tag{3}$$

$$P = \frac{3600 \times E}{\Delta t} \tag{4}$$

Where υ represents the scan rate, ΔV (V) and Δt (sec) show the potential CV curve and discharge time window. I (Amp) is the discharge current. $m+ / m-$ is the ratio of the masses of the positive and negative electrodes. η is coulombic efficiency, C+/C-, and V+/V- are the capacitances and potential windows of the positive and negative electrodes of the CV curves, respectively.

2. BET analysis

To surface area of the samples porous was further examined by N_2 adsorption/desorption isotherms, as depicted in Fig. S1. Mesopores were present in all four samples, as revealed by the presence of type IV isotherms. It is evident that the prepared KT-2 composite's BET surface area was much 44.7 m^2g^{-1} higher than KT-1(38.4 m^2g^{-1}), FeSe2 (29.3m^2g^{-1}) and TiO2 (25.2 m^2g^{-1}) samples' respective values. The high surface area ensure the high capacitance of the KT-2 sample, which can be explored in the electrochemical analysis. The inset in Fig. S-1 exhibits the pore size distribution curves of the Fe-SNC and SNC. It is clear that KT-2 has a 23.8 nm pore size distribution, demonstrating the mesoporosity with larger pore diameter, enabling the excessive accumulation of ion diffusion during intercalation/deintercalation process, whereas TiO_2, $FeSe_2$, and KT-1 have 22.5 nm 23.2nm and 23.5 nm pores, respectively. These results show that the mesoporous nanostructures of the four samples have a significant surface area, which is essential for efficient electrochemical performance.

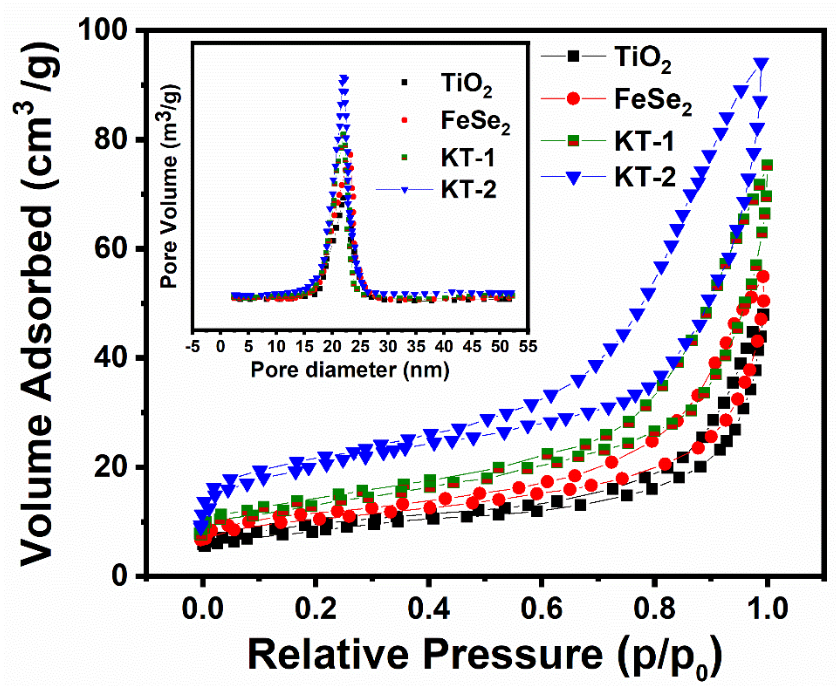

Fig: S-1 The Brunauer-Emmett-Teller (BET) surface area was determined using nitrogen adsorption/desorption isotherms, and the insets show the associated pore-size distribution of the (a) TiO_2, (b) $FeSe_2$ and (c) KT-1 and (d) KT-2 samples.