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WC (Tungsten Carbide) : A Novel Material for Electrochemical Energy Conservation and Storage

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The present report deals with development and electrochemical investigation of metal carbide based energy storage systems with WC (60 nm) as a model electrode material. This is in view to extend the understanding towards tailoring and designing other transition metal carbides based electrochemical energy conservation and storage systems with desired activity and stability.

Nano structured metal carbides has recently received accelerated interest as materials for enhanced electrochemical energy storage due to their appealing electrical conductivity, chemical, thermal and electrochemical stabilities^{1,2}. This has been in view to develop the inexpensive and durable capacitors and batteries to meet out the power shortage in domestic, industrial and defense sectors³. The early applications of metal carbides in development of tools, industrial catalysis, and protective coatings in fusion reactors⁴⁻⁶ has now turned into fabrication of electrodes for batteries and fuel cells^{7,8}.

Recently, tungsten carbide has also been intensively studied in the field of electrocatalyst and fuel cell material due to its high electrical conductivity, reasonable cost, platinum like catalytic behavior, good hardness, excellent selectivity and stability under harsh environment^{10,11}. Tungsten carbide generally appears as WC, W₂C and WC_{1-x}^{12, 13}. The better tolerance of WC enhances its importance as electrode materials for batteries and fuel cells¹⁴. The characteristic hexagonal structure of WC involves small carbon atoms distributed into interstitial space of a densely packed host lattice. This imparts high melting point (2600 °C), hardness, thermal and electrical conductivity. The electrochemical behavior of tungsten carbide is strongly dependent on its surface composition and condition. Thus, carbon content of surface layers is decisive for the electrochemical performance of WC¹⁵.

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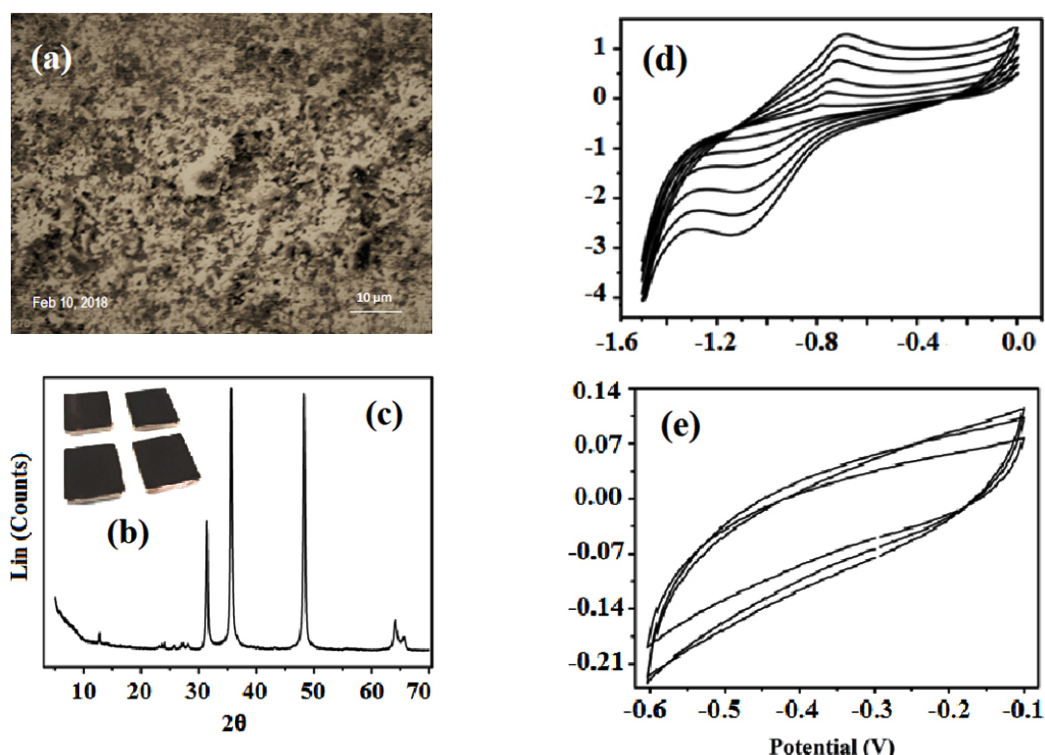


Fig.1: Scanning electron micrographs of electrodes (a), Physical appearance of electrodes (b) with retained characteristics of WC through XRD spectrum (c), Redox (d) and Supercapacitance behavior (e) of electrode in 1.0 M LiCl in aqueous medium.

The pioneer efforts have been made towards fabrication and investigation of electrochemical behavior of electrodes derived through dispersion of WC into graphite matrix in presence of an ionic polymer as binder. Scanning electron microscopy reveals high quality dispersion of WC into graphite [Fig.1(a)]. The electrode preserves the XRD peaks of WC in graphite matrix [Fig.1(c)]. Electrodes display well electrochemical behavior under three electrode assembly systems in LiCl (1.0M) @ 0.2 V/s under potential window of 0.0 to -1.5 V [Fig.1(d)]. This has raised the anodic peak current up to 1.87 mA and cathodic peak current to -2.92 mA. The increase in the peak current with scan rate attributes to good reversibility of electrodes during the charge-discharge process. Further, the polarization of the electrode under high scan rate attributes to the increased potential difference between anodic and cathodic peaks 16.

Conclusion

Electrodes display enhanced stability and cyclability up to 0.1 V/s without noticeable decomposition indicating their suitability as electrode materials. Under optimized composition, potential window and scan rate, WC based electrodes of the present study delivers supercapacitance up to 235 F/g in LiCl (1M) [Fig.1(e)].

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