Recovery of Cobalt as CoS from Spent Li-ion Batteries and investigation of Supercapacitor performance of its composite with Cl-doped Graphene Oxide

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Batteries are currently the most widely used electrical energy storage technology in commercial applications. One of these battery kinds, secondary batteries, is also known as a rechargeable battery. They can be recharged by running electricity through the cells, and they are reusable [1].

The main electroactive materials used in the cathodes of commercial lithium-ion batteries (LIBs) are lithium metal oxides, such as $LiCoO_2$ (LCO), $LiNiO_2$, $LiMn_2O_4$, Li (Ni-Co-Mn)O_2 alloys, and $LiMPO_4$ (M: Metal) type compounds [2].

Lithium cobalt oxide (LCO) is the first cathode to be commercialized [3]. In the recycling of LCO, Leaching can be performed by using acid solution like HNO_3. Additionally, using H_2O_2 during LCO leaching operations readily converts Co^{+3} ions to Co^{+2} ions [4]. A new approach to the recycling of LCO is the leaching of LCO and precipitation of cobalt in the solution as cobalt sulfide. Then it can be used as supercapacitor electrode material [5], [6].

Experimental procedure of this study includes crushing of spent battery, dismantle of Li-on cell (LCO), stripping of cathode material from membrane, leaching of cathode material, precipitating of CoS by using Na_2S source, producing of Cl-doped graphene oxide (Cl-GO), preparing of electrode material for coin cell type supercapacitor by mixing COS and Cl-GO with PVDF and lastly, electrochemical measurements of supercapacitor by Using cyclic voltammetry (CV), galvanostatic charge/discharge (GCD), and electrochemical impedance spectroscopy (EIS) tests. Experimental flow chart is shown at (Fig 1).

Produced materials were characterized by using FE-SEM, XPS, FTIR, BET. Electrochemical performance of the coin cell type supercapacitors were characterized EIS, CV and GCD tests. The produced supercapacitor showed enhanced capacitive property and cycle life. This work also showed a successful application of reusing of spent li-on battery active materials as an active material of a new energy storage device. This study brought an effective use of limited source for greener world.

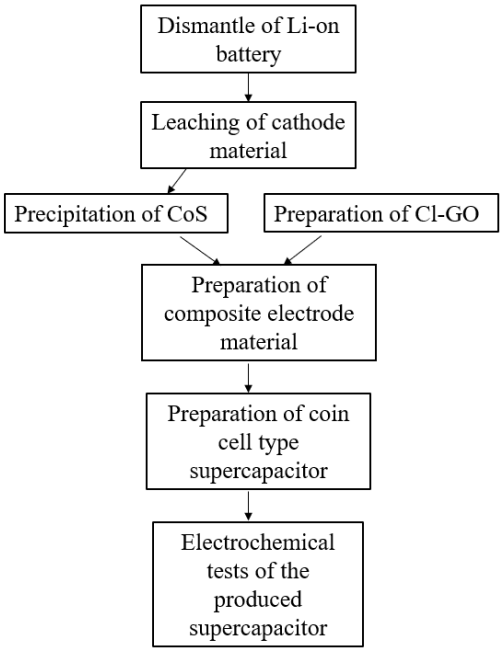

Figure 1. Experimental flow chart

References

[1] J. Theerthagiri, R. A. Senthil, P. Nithyadharseni, S. J. Lee, G. Durai, P. Kuppusami, J. Madhavan and M. Y. Choi, *Ceram. Int.*, 2020, **46**, 14317–14345.
[2] C. S. dos Santos, J. C. Alves, S. P. da Silva, L. Evangelista Sita, P. R. C. da Silva, L. C. de Almeida and J. Scarminio, *J. Hazard. Mater.*, 2019, **362**, 458–466.
[3] K. Mizushima, P. C. Jones, P. J. Wiseman and J. B. Goodenough, *Solid State Ionics*, 1981, **3**–**4**, 171–174.
[4] C. K. Lee and K. I. Rhee, *J. Power Sources*, 2002, **109**, 17–21.
[5] H. Chen, X. Zhu, Y. Chang, J. Cai and R. Zhao, Mater. Lett., 2018, 218, 40–43.
[6] Yasa, S., Birol, B., & Gencten, M. New Journal of Chemistry, (2023), 47(13), 6224-6234.

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