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Cathodes – Materials Review

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Abstract. The electrochemical potential of cathode materials defines the positive side of the terminal voltage of a battery. Traditionally, cathode materials are the energy limiting or voltage limiting electrode.

It started with the Volta pile, a copper-zinc galvanic element as one of the first electrochemical batteries, in 1800 (Phil. Trans. Roy. Soc. 90, 403–431) with a terminal voltage of 0.76 V. Since then, the research community tried to increase capacity and voltage for primary (non-rechargeable) batteries and round trip efficiency for secondary (rechargeable) batteries. Successful secondary batteries, have been Pb-acid with a lead oxide cathode and a terminal voltage of 2.1 V and later NiCd with a nickel(III) oxide-hydroxide cathode and a 1.2 V terminal voltage.

The relatively low voltage of those aqueous systems and the low round trip efficiency due to activation energies in the conversion reactions limited their use.

In 1976, Wittingham (J. Electrochem. Soc., 123, 315) and Besenhard (J Power Sources 1 (3): 267) finally enabled highly reversible redox-reactions by intercalation of lithium ions instead of a chemical conversion. In 1980, Goodenough and Mizushima (Mater. Res. Bull. 15, 783–789) demonstrated a high-energy and high-power $LiCoO_2$ cathode allowing for an increase of terminal voltage far beyond 3 V. Over the past 4 decades, the international research community has further developed cathode materials of a large variety. Current state of the art cathodes demonstrate voltages beyond any known electrolyte stability window bringing electrolyte research to the new forefront of battery research.

This talk will summarize the described cathode developments, present the state of the art, and the future efforts needed for this technology to become truly enabling for a brighter energy future.