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The Wolfson Department of Chemical Engineering

Wolfson Department of Chemical Engineering Seminar

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Zoom meeting link: https://technion.zoom.us/j/93912704173?from=addon

Tailoring the Structure of Electrospun Nanofibers for Energy Applications

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PhD Final Seminar

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Modern energy systems face a dual challenge: to reduce anthropogenic carbon dioxide (CO_2) emissions due to fossil fuel usage, and to raise efficiency during generation, conversion, and utilization. Despite growth in low carbon technologies, large fractions of primary energy are still lost as waste-heat, and CO_2 remains the dominant greenhouse gas. Meeting these challenges requires materials that convert nanoscale structural control into macroscale function, with reliable operation under demanding conditions. One dimensional (1D) textured nanostructures are compelling in this regard as they provide high surface area, short transport lengths, directional pathways, and form interconnected networks that enable precise control of charge, heat, and mass transport.

This research uses electrospinning as a platform for nanostructure design and tailoring. A unified pathway is established from solution formulation, through controlled spinning of continuous fiber mats, to staged thermal conversion that fixes ceramic phase, crystallinity, and microstructure. The approach is demonstrated in two energy directions. For catalysis, electrospun Al_2O_3 nanofibers act as open scaffolds on which Cu/Al_2O_3 and $Cu/ZnO/Al_2O_3$ nanosheets nucleate in situ, wrapping each fiber to create hierarchical shells that expose well-dispersed, nanometer scale Cu sites, shorten diffusion paths, and strengthen interfacial coupling for CO_2 hydrogenation to methanol and dimethyl ether. For thermoelectrics, solution engineering and process control drive the formation of flat ribbon-like fibers with parallel alignment; conversion to calcium cobaltite $Ca_3Co_4O_9$ and sodium cobaltite $Na_xCo_2O_4$ preserves orientation and imparts crystallographic texture within the ribbon plane. During consolidation, face to face stacking transfers this alignment to the ceramic, increasing density and promoting electronic transport within the plane where the Seebeck coefficient is maximized.

In summary, the research demonstrates a design driven route from solution to ceramic that connects processing, architecture, and performance in two directions: CO_2 hydrogenation to alternative fuels over hierarchical nanofiber catalysts, and ribbon-based cobaltite ceramics for solid-state waste heat harvesting.