THE DEPARTMENT OF CHEMICAL & ENVIRONMENTAL ENGINEERING AND THE MATERIALS SCIENCE & ENGINEERING PROGRAM JOINT COLLOQUIUM

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CHALLENGES IN PROCESSING OF FUNCTIONALIZED GRAPHENE AND ITS USE IN APPLICATIONS

Pristine graphene isolated from graphite by mechanical peeling has served an invaluable role in studies leading to fundamentals. In contrast, defective and functionalized graphene which is produced through splitting and reduction of graphite oxide, to C/O ratios higher than 10, promises to find entry into a myriad of applications more rapidly. This is mainly because (i) for the development of bulk materials such as ultracapacitors, electrodes for batteries, electrochemical sensors, and graphene-based composites in general, there is a need to produce graphene in > tons/year quantities and (ii) the intrinsically defective and functionalized structure of graphene produced by graphite oxide route provides advantages over pristine graphene in various applications. In this presentation, I will focus on the production and the utilization of functionalized graphene sheets (FGSs) by thermal exfoliation and reduction of graphite oxide. In spite of its rich history dating back to 1840, only recently it has been shown that the thermal exfoliation and reduction of graphite oxide method can indeed yield large fractions (> 80%) of single sheets. The challenge of single sheet production, however, leads into another challenge on the control of aggregate structures as single sheets readily collapse back to form multistacks due to van der Waals and capillary forces. Thus, restacking is not only unavoidable but a certain degree of restacking is also beneficial in most applications. The main challenge is the control of the aggregated network structures to attain the desired properties in applications ranging from electrochemical devices to high strength multifunctional nanocomposites. The reduction of the contact resistance of graphene aggregates is another challenge when high electrical conductivity is a target. While the intrinsic electrical conductivity of functionalized graphene has been shown to be in the order $4x10^5$ S/m, in graphene aggregates, the conductivities are at least three orders of magnitude lower mainly due to contact resistance problems. An effective solution for this problem remains to be demonstrated.

Ilhan Aksay is a Professor in the Department of Chemical and Biological Engineering of Princeton University. He earned his B.Sc. (1967) in ceramic engineering at the University of Washington and his M.Sc. (1969) and Ph.D. (1973) in materials science and engineering at the University of California, Berkeley. Prior to joining Princeton in 1992, his teaching and research affiliations included appointments at the University of Washington, Seattle (1983-92); University of California, Los Angeles (1981-83); the Middle East Technical University, Ankara, Turkey (1975-81); and Xerox Corporation, Webster Research Center, Webster, New York (1973-75). At the University of Washington, he held the Battelle, Pacific Northwest Laboratory Professorship in the Department of Materials Science and Engineering (1987-92).

His research activities include the processing science of ceramic matrix composites, thermodynamics and phase equilibria in materials systems, diffusion and structural studies in ionic systems, interfacial reactions and capillarity phenomena, and the utilization of self-assembly techniques in materials processing. In recent years, Prof. Aksay's work has been heavily influenced by biomimetics and bioinspired processing, focusing on the use of complex fluids to control the architecture of organic/ceramic nanocomposites. He and his coworkers' research has been recognized not only by contributions to the literature on the fundamentals of ceramic processing (over 350 articles) but also by products produced by the industry, holding more than 30 patents in materials processing. His group has submitted 16 invention disclosures and patent applications related to graphene and its processing and applications.