Plasmonics for Sustainability and Societal Impact

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Metallic nanoparticles, used since antiquity to impart intense, vibrant color into materials, then brought to scientific attention in the 19th century as "Faraday's colloid", have more recently become a central tool in the nanoscale manipulation of light. When excited by light, metallic nanoparticles undergo a coherent oscillation of their conduction electrons- known as a plasmon- which is responsible for their strong light-matter interactions and properties: they can be thought of as "optical antennas". One result of light illuminating metal nanoparticles is strong photothermal heating, a property that we originally introduced into biomedicine for highly localized cancer therapy. Now, years after their initial demonstration, this approach has been used in successful human trials for the precise and highly localized ablation of cancerous regions of the prostate, eliminating the deleterious side effects characteristic of conventional prostate cancer therapies. A second outcome of illuminating metal nanoparticles is the generation of nonequilibrium, or "hot" electrons, that can drive chemical processes very efficiently. By coupling optical antennas and catalyst particles, one can transform heat-driven chemical reactions into photodriven reactions that proceed under surprisingly mild, low temperature conditions. This new type of light-based catalyst- an antenna-reactor nanoparticle complex- can be utilized for remediating greenhouse gases, converting them to useful molecules for industry, or into benign chemicals for a cleaner planet.