like metallic conductors and semiconductors was a chemistry first.

The key breakthrough leading to practical application as batteries occurred in 1979 when one of Professor McDiarmid's graduate students was investigating alternative ways for doping polyacetylene. He placed two strips of polyacetylene in a solution containing the doping ions and passed an electric current from strip to strip. As expected, the positive ions migrated to one strip and the negative ions to the other. But when the current source was removed, the charge remained stored in the polyacetylene polymer. This stored charge could then be discharged if an electrical load was connected between the two strips, just as in a conventional battery.

Chemically, the plastic battery is different from conventional metal-based rechargeable batteries in which material from one plate migrates to another plate and back in a reversible chemical reaction. In a conducting plastic battery, only the stored ions of the solution move—the plates are not consumed and reconstituted. Since conventional battery life is limited by the number of times the plates can be reconstituted, this difference portends a longer recharge-cycle lifetime for the plastic batteries.

One potential application for polymer batteries is in battery-powered automobiles. Two key measures of a battery's suitability for automotive application are the power density, which determines acceleration and hill-climbing ability, and the energy density, which determines the number of miles that can be driven between charges. Polyacetylene's power density is 12 times that of ordinary lead acid batteries. Its energy density is also higher—about 50 watts-hours per kilogram versus 35 for lead acid batteries. Although plastic batteries are competing against other advanced development batteries with similar capability for this application, they have the unique potential to be made of low-cost, environmentally-benign materials. Supporters feel that a polymer battery can be part of the battery-powered car of the future.

Polyacetylene, however, is not an ideal battery material. It degrades in air, is chemically stable only in liquid solutions, and is brittle and not amenable to injection molding methods used for forming plastic parts in production. The University of Pennsylvania team, along with industrial associates licensed to use their technology, searched for conducting polymers of greater structural strength, thermoplasticity, flexibility, and lower costs. Allied Corporation synthesized a new material, polyparaphenylene, a black powder capable of being formed into plates by hot pressing, that could be doped to conduct electricity. Several other potentially suitable plastics were discovered thereafter.

One such material was polyaniline. In 1984 and 1985, the University of Pennsylvania group received patents on the use of this material for rechargeable batteries. It is inexpensive, and, unlike polyacetylene, it is stable in both air and water. Polyaniline is the material used in the plastic batteries that first became commercially available in 1987.

In just 8 years, plastic batteries went from laboratory discovery to commercial availability, a remarkably fast evolution. With advances continuing at a rapid pace, there are great opportunities for increasingly important applications of this new technology.