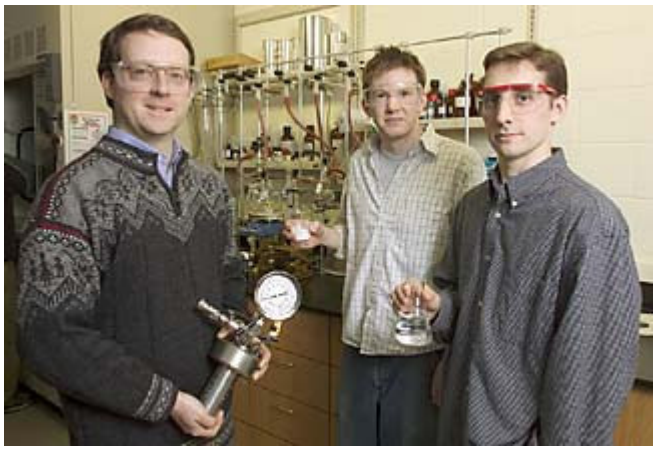
# Putting the squeeze on petroleum: Chemists make plastics from oranges

**By Sarah Davidson**

A Cornell research group has made a sweet and environmentally beneficial discovery -- how to make plastics from citrus fruits, such as oranges, and carbon dioxide.



**From left, Professor Geoffrey Coates holds the reactor he used to make a polymer using a citrus fruit extract and carbon dioxide, as postdoctoral chemistry associate Scott Allen and chemistry doctoral student Chris Byrne display other ingredients essential to the novel process in Olin Lab Jan. 14. Byrne is holding a flask of limonene oxide (oxidized orange peel oil), and Allen holds a beaker containing the polymer they created using a catalyst.** *Nicola Kountoupes/University Photography*

In a paper in a recent issue of the *Journal of the American Chemical Society* (September 2004), Geoffrey Coates, a Cornell professor of chemistry and chemical biology, and his graduate students Chris Byrne and Scott Allen describe a way to make polymers using limonene oxide and carbon dioxide, with the help of a novel "helper molecule" -- a catalyst developed in the researchers' laboratory.

Limonene is a carbon-based compound produced in more than 300 plant species. In oranges it makes up about 95 percent of the oil in the peel.

In industry, Coates explains, the orange peel oil is extracted for various uses, such as giving household cleaners their citrus scent. The oil can be oxidized to create limonene oxide. This is the reactive compound that Coates and his collaborators used as a building block.

The other building block they used was carbon dioxide ($CO_2$), an atmospheric gas that has been rising steadily over the past century and a half -- due largely to the combustion of fossil fuels -- becoming an environmentally harmful greenhouse gas.

By using their catalyst to combine the limonene oxide and $CO_2$, the Coates group produced a novel polymer -- called polylimonene carbonate -- that has many of the characteristics of polystyrene, a petroleum-based plastic currently used to make many disposable plastic products.

"The polymer is a repeating unit, much like a strand of paper dolls. But instead of repeating dolls, the components alternate between limonene oxide and $CO_2$ -- in the polymer," said Coates. Neither limonene oxide nor $CO_2$ form polymers on their own, but when they are put together, a promising product is created.

"Almost every plastic out there, from the polyester in clothing to the plastics used for food packaging and electronics, goes back to the use of petroleum as a building block," Coates observed. "If you can get away from using [petroleum-based] oil and instead use readily abundant, renewable and cheap resources instead, then that's something we need to investigate. What's exciting about this work is that from completely renewable resources, we were able to make a plastic with very nice qualities."

The Coates research team is particularly interested in using $CO_2$ as an alternative building block for polymers. Instead of being pumped into the atmosphere as a waste product, $CO_2$ could be isolated for use in producing plastics, such as polylimonene carbonate.

The Coates laboratory is made up of 18 chemists, about half of them striving to make recyclable and biodegradable materials out of cheap, readily available and environmentally friendly building blocks. "Today we use things once and throw them away because plastics are cheap and abundant -- it won't be like that in the future," says Coates. "At some point we will look back and say, 'Wow, remember when we would take plastic containers and just throw them away?'"

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*Sarah Davidson is a Cornell News Service science writer intern.*

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