ENGINEERS have long dreamed of shortening the time it takes to recharge batteries. Currently, that can be hours. For applications like motor vehicles it really needs to be reduced to minutes. Now Paul Braun and his colleagues at the University of Illinois, Urbana-Champaign, have succeeded in building prototype batteries which do just that. Their most successful attempt can be recharged almost fully in a mere two minutes.

All batteries, no matter what their exact composition, work in the same fundamental way. They have two electrodes, an anode and a cathode, that are connected by an electrically conductive material—generally a liquid—called an electrolyte. When a battery is discharging, electrons (which are negatively charged) flow from anode to cathode through an external circuit, where they are put to work, and positively charged ions flow from anode to cathode through the electrolyte, to balance the charges in both electrodes. During recharging, electrons are forced round the circuit in the opposite direction, and the ions, perforce, return whence they came.

Many materials can be used as positive ions in batteries, but lithium has become popular in recent years because it is light and, weight for weight, lithium batteries thus store more energy than any other kind. Before that, nickel-metal hydride batteries were preferred for many applications. Even now, they are cheaper than lithium-ion batteries and they, too, are still widely used. Dr Braun therefore decided to have a go at making rapidly chargeable versions of both.

The battery-maker’s dilemma is that the recharging rate depends on the area of contact between electrolyte and electrode. A thin, sandwich-like arrangement, in which cathode, electrolyte and anode are close together, can thus be discharged and recharged rapidly. However, this speed comes at a price. The amount of energy a battery can store depends on the volume of its electrodes, so a thin battery does not last long. What is needed is a way to increase contact area without sacrificing volume. And that is what Dr Braun has found. Moreover, his solution looks suitable for mass production.

His starting material, as he describes in a paper in *Nature Nanotechnology*, is made of closely packed polystyrene spheres about a millionth of a metre in diameter. This is an arrangement similar to that found in opal (except that in opal the spheres are made of silica) and the result is, indeed, opalescent.

The next stage is to fill the gaps between the spheres with nickel. This is done by electrodeposition—like nickel-plating a piece of steel. After that, the material is heated, to melt the polystyrene. This leaves a sponge made of metallic nickel. The connections between the spherical gaps in the sponge are then enlarged, using a technique called electropolishing to dissolve the surface layer of the metal. This creates an electrically conductive framework suitable for smothering with materials normally used to make cathodes.

For the nickel-metal hydride version of the battery, that material is a substance called nickel oxyhydroxide. For the lithium-ion version, it is manganese dioxide spiked with lithium ions. In both cases these are electroplated onto the structure before the remaining gaps are filled with liquid electrolyte.

The result is a huge area of contact between the nickel (which conducts electrons to and from the battery), the cathode (which conducts ions to and from the electrolyte to compensate for the movement of those electrons), and the electrolyte (through which the ions are moving between cathode and anode)—but without a significant loss of cathode volume. Just, in other words, what
the doctor ordered.

The consequence, according to Dr Braun, is a charging rate ten to 100 times higher than that of a normal, commercial battery (in one instance, the researchers created a lithium-ion battery that could be 90% recharged in two minutes), at a probable increase in production cost, once the process is properly industrialised, of 20-30%. And that rate might be improved still further if similar techniques were applied to the anode—a task that Dr Braun is now working on.

It is not quite as simple as that. Somehow, it never is. To take advantage of fast-charging batteries, a car's electrics will have to be hardened up to cope with the huge amperage involved. If they can be, though, it would allow electric cars to be recharged on the road in the same amount of time that a driver now spends putting petrol in his tank. And at that point the other advantages of electric motors (mechanical simplicity, huge acceleration and silent running) would probably trump the old-fashioned internal-combustion engine in the minds of most motorists, and the long-promised revolution of electric motoring might finally come to pass.