



Big Accomplishments for a Small Particle

In 1990, Atomic Energy of Canada Ltd. (AECL) received an award for developing one of the 100 most-significant technical products of the year. This product is a family of electron accelerators that are called IMPELA (Industrial Materials Processing Electron Linear Accelerator), developed by J. McKeown at AECL's Chalk River Laboratory in Ontario. McKeown's initial project was to research and develop a proton accelerator to create a new source of fuel for generation of nuclear power. In order to make things easier, a smaller and less complicated electron accelerator was designed to create high energy electron beams that could model the behaviour of high energy proton beams. These efforts led to the development of IMPELA.

The source of the electrons for the electron beam is simple. It comes from plugging the instrument (IMPELA) into the socket in the wall. This supplies the power to heat the wires within the electron gun (just like the one in your T.V.) from which the electrons are generated and then extracted. The electrons are then directed from the heated wire to the accelerator and the accelerator does its job by speeding up the electrons and concentrating them into a single beam that generates from 5 to 18 MeV (million electron volts) of energy and supplies a range of 20 to 250 kilowatts of power (energy/second). This newly developed electron accelerator is appreciated because no other accelerator can provide both a high energy and a high powered electron beam. The more energy the electron beam has, the deeper the electrons can penetrate the target material and therefore, the more applications the beam can provide.

Now that we have this concentrated, fast moving electron beam, what can we do with it? Well, we can affix this electron beam on different materials to modify their chemistry by inducing such processes as polymerization, cross-linking and free radical activation. How does it work? You've probably heard of X-rays. IMPELA generates X-rays which are high energy light particles (or photons). The beam of electrons does this by bombarding the target atoms and displacing an electron in the inner shell. The vacancy created is then filled by an electron from a higher energy level and therefore, an X-ray is emitted during the transition to the lower energy level. Also, the electron beam can remove valence (outer) electrons from the target atoms and cause them to be very unstable and reactive. As a result of these high energy intermediates, chemical reactions and chemical changes take place within the target material.

One valuable use of this process is in the cellulose industry. Cellulose is a polymer found in the cell wall of plants and is the most abundant natural polymer in the world (a polymer is made up of repeating units that are strung together like beads to make a very large molecule). This polymer is extracted from wood chips in a process known as pulping. Cellulose is the starting material for paper and viscose, and pre-treatment with the electron beam makes the cellulose much more accessible to the chemicals used in the pulping process (carbon disulfide, alkali, and acid). Therefore, electron processing greatly reduces the volume of chemical use. The viscose obtained from cellulose is used in products such as clothing, tapes, textiles, cellophane and reinforced hose and belts.

The electron beam can also be used to reduce the use of hazardous chemicals in the plastics industry to cure (polymerize), cross-link (join adjacent polymer chains together), and graft (attach new molecules to the surface of the polymer) polymer materials. This decrease in chemical use and the replacement of gamma rays, emitted from radioactive sources such as cobalt-60, by electron beams in certain applications renders the electron beam environmentally friendly. The electron beam also kills bacteria, viruses, and fungi and can be used in the sterilization of medical supplies, in the disinfestation of agricultural products, as well as in the treatment of waste water (sewage).