Creating safer, cleaner materials through nuclear processing

By Andrew Green

This bandage has a hydrogel sheet that promotes wound healing and is easier and less painful to remove.
(Photo: S. Henriques/IAEA)

From water filters and lampshades to the soles of shoes and medical bandages, an increasing number of consumer products are now being manufactured with new materials produced using nuclear techniques.

"New developments in the processing of certain polymers are improving productivity and leading to a reduced burden on the environment," said Masao Tamada, Director General of the Takasaki Advanced Radiation Research Institute in the Nuclear Science Research Sector at the Japan Atomic Energy Agency and a renowned expert in the field.

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The IAEA provides a platform for cooperation in this area, by supporting experienced experts such as Tamada to train professionals from other countries in the development of these specialized plastic and gel-based materials.

Leading an IAEA regional training course in Malaysia in August 2016, Tamada taught advanced methods of radiation grafting for environmental and industrial applications to participants from Bangladesh, China, India, Indonesia, Malaysia, Myanmar, Pakistan, the Philippines, the Republic of South Korea, Sri Lanka, Thailand and Viet Nam. In an earlier IAEA workshop, Tamada prepared a protocol for specialized methods in radiation grafting, which is now accessible online.

New medical applications of radiation-processed polymers

By using radiation, such as gamma rays, X-rays, accelerated electrons or ion beams, polymers such as plastics or gel-based materials can be modified or strengthened to create new and more resistant bond formations (see The Science box). Strengthening and improving polymers with radiation is a technique that has been used for decades to produce commercial products such as heat-resistant parts in car engines and heat-shrinkable tubes, foam sheets and tyres.

New developments in the radiation processing industry are leading to more novel and innovative uses of irradiated polymers, such as hydrogel sheets for use in medicine to manage burns and wounds, as well as in radiotherapy to treat cancer.

"Hydrogel sheets with high water concentration, which are created by using

radiation to cross-link materials, enable wounds to heal faster than if the sheets were dry," explained Tamada. "Only by using irradiation to cross-link polymers are we able to produce such elastic hydrogels with high water concentration."

The same clear and transparent gels can be used in radiotherapy to help measure and maintain safe and effective doses of radiation, an area known as dosimetry. The hydrogel sheets can be used to identify simultaneously both radiation levels and the areas exposed to radiation, which may vary from patient to patient. This is helpful to know when preparing radiotherapy sessions, noted Tamada.

"The sheets can also be removed with less pain than conventional medical gauze, and because they are transparent, medical hydrogels allow continuous monitoring of the healing process," said Tamada.

Hydrogel bandages created using radiation can be used to treat burns and wounds.
(Photo: S. Henriques/IAEA)

THE SCIENCE

Cross-linking polymers with radiation

Plastic and gel-based materials are formed using polymer chains that are cross-linked and sterilized using gamma radiation or electron beams. The polymers are mixed in water, put into moulds or tubes, packaged, sealed and then cross-linked and sterilized through exposure to radiation. Radiation cross-linking techniques are also much safer than chemical techniques. No impurities are created because no chemicals are used. The radiation can break down chemical bonds and create new ones that change the chemical, physical, and biological properties of a material without additional chemical processing and without making the material radioactive. This makes it possible to redesign polymers at the molecular level to serve a specific purpose.

In the case of hydrogels, the cross-linking results in the polymers connecting to form a gel. The gel formed is strong, pliable and transparent. Hydrogels for wound dressings contain 70–95% water and are biocompatible. They do not stick to the wound; they keep the wound moist to aid recovery, absorb the excreta and are also easy to store and use.

The cross-linked polymers inside this white wound dressing have been formed into a gel that contains 70-95% water and is biocompatible.
(Photo: S. Henriques/IAEA)