

**SNETP Forum** 

## Polymers in nuclear power



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#### Introduction

The effect of radiation cross-linking of polyethylene was noticed while observing the insulation of cables used in nuclear reactor rooms. Quite unexpectedly, irradiated PE not only did not reduce the parameters, but on the contrary increased the mechanical and thermal resistance. Dole showed that cross-linking of PE is accompanied by the release of  $H_2$ . He also proved that in the process of radiolysis, mainly carbon-hydrogen bonds break, and not carbon-carbon, as could be assumed. increased resistance to abrasion, improved impact strength at low temperatures and reduced dripping during combustion and reduced effects of short circuits.





The energy of ionizing radiation is deposited in matter in a inhomogeneous manner. In singleionization spurs, an electron is ejected. In multiionization spurs, direct degradation of the polymer chain occurs.

Ionizing radiation allows for a unique way of delivering energy to a polymer at any temperature throughout the entire volume of the material. It affects all components in proportion to their percentage share or, more precisely, electron contribution.

# H<sub>2</sub> emission in radioactive waste storage facilities



Cross-linking of cables using an electron beam. Radiation cross-linked and non-cross-linked polyethylene foam. Temperature 220 °C, 10 min

### **Polymer composites barrier to ionizing radiation**

A characteristic feature of polymer composites is the ability to modify their structural and protective properties according to needs. They can be used, among others, in: nuclear research centers, radioactive waste storage facilities, nuclear power plants, nuclear fuel cycle plants, nuclear medicine plants, research centers. They are used to make: protective covers, plasters for reinforcing walls, protective covers used during the liquidation of radioactive objects, syringe covers, glove boxes, temporary covers, etc.

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Polymer	H <sub>2</sub> [μmol/J]
PP primary	0.40
PP isotactic	0.26
PP syndiotactic	0.33
Parafilm	0.34
Borealis FA 3220	0.41
Borealis FT 5230	0.49
NBR N33	0.12
Therban A3407	0.14
Therban A4550	0.12
Alanin L	0.019
Alanin LD	0.024
Alanin β	0.19

In the polymer radiolysis studies we used the straight beam of the LAE 13/9 accelerator, gamma radiation sources and the GC2014 Gas Chromatograph.

### Radiation modification of electrical cables and wires

The example of irradiation of polyethylene foams explains the principle of beneficial modification of polymers through radiation formation of cross-links. This is accompanied by the separation of hydrogen atoms from chains. We obtain a product with better dielectric properties compared to chemical cross-linking. The process is faster, carried out in a smaller space, uses less energy, is easier to control. In addition, radiation technology does not require chemical initiators or an additional heating stage and allows the use of thinner polymer layers. Plastics are characterized by an increased temperature of use, reduced deformation under load, increased resistance to chemicals, caustics and oils,

### Hydrogen barrier polymer composites

The first work on the use of polymer composites (reinforced with carbon fiber) for these purposes was carried out in the 1970s. Today, more durable and economically viable materials are sought. We conduct research on the radiation cross-linking of polymers in order to strengthen the so-called composite reinforcement. The uniqueness of the technology lies in the fact that the product (tank) is modified at ambient temperature after it has been formed. The cross-linking phenomenon can be easily controlled by the radiation dose (irradiation time). A new direction of research is the assessment of the effect of radiation treatment on the properties of oxide materials synthesized using the sol-gel method. An innovative barrier coating based on  $SiO_2$ , due to its previously unattainable tightness, can, in combination with radiation modification of composites, solve the problem of hydrogen losses during its storage, transport and transmission.

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