



**Research Project: "Ionizing Radiation and Plasma discharge Mediating Covalent Linking of Stratified Composites Materials for Food Packaging"**, Part of Coordinated Project: "Application of Radiation Technology in the Development of Advanced Packaging Materials for Food Products". **IAEA** Research Contract No: **17689 (RC-17689-R0)**

**Chief Scientific Investigator of the Project: Prof. Assoc. Dr. Cornelia Vasile**

**Research team:**

**Dr. Elena Stoleru**

**Dr. Anamaria Irimia** — person in charge with administrative  
and financial management

**Dr. Traian Zaharescu**

**Dr. Emil Ghiocel Ioanid**

**Ec. Lucia Mocanu**

**Period : 2013 –2015**

# Objectives



**Main Objective:** The use of ionizing radiation and plasma gas discharge for developing new surface active polymeric materials with special properties for food packaging application.

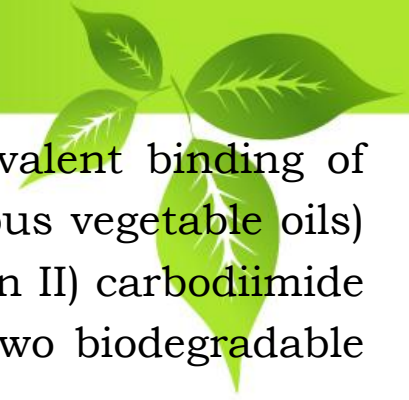
The **specific objectives of the project** are classified in two major directions:  
I) the activation of polymeric materials using ionizing radiation and plasma gas discharge technologies. *By application of these surface activation/functionalization techniques the bulk properties of polymers are maintained.*

II) the functionalization with active/bioactive compounds by several coating/immobilization procedures.

**(1):** The surface activated synthetic polymers namely **polyolefins (PO) and poly (lactic acid) (PLA)**, will be further coated with active/bioactive compounds like chitosan, lactoferrin, vitamin E, vitamin C and beta carotene, individually or mixed together.

**(2):** Surface activated **cellulose-based materials** will be grafted with different phenolic compounds (p-hydroxybenzoic acid, caffeic acid, gallic acid, eugenol and thymol) and vegetable oils by impregnation and/or coupling reaction.

# Achievements



✓ New surface functionalized materials have been obtained by covalent binding of some bioactive components (chitosan and vitamin E and C and various vegetable oils) by a two step procedure: I) cold plasma or ionizing radiation activation II) carbodiimide coupling reaction (EDC+NHS) onto PE, PLA and cellulosic surface: two biodegradable and one non-biodegradable substrate were chosen.

✓ For all modified substrates by plasma activation or gamma irradiation the following orders were established:

➤ *Poly(lactic acid) (PLA) packaging material* antioxidant activity:  $\text{PLA/cp N}_2/\text{EDC+NHS/LF} < \text{PLA/cp N}_2/\text{EDC+NHS/CHT} < \text{PLA/20kGy/EDC+NHS/LF} < \text{PLA/20kGy/EDC+NHS/CHT}$ , while in respect with antibacterial activity:  $\text{PLA/cp N}_2/\text{EDC+NHS/LF} < \text{PLA/20kGy/EDC+NHS/LF} \approx \text{PLA/20kGy/EDC+NHS/CHT} \approx \text{PLA/cp N}_2/\text{EDC+NHS/CHT}$ .

➤ *Cellulose (CC) packaging materials*, in case of plasma activation the following order of the antimicrobial properties was established:  $\text{CC/cp air/RO} > \text{CC/20kGy/GO} > \text{CC/cp air/Eu} > \text{CC/20kGy/RO} > \text{CC/20kGy/Eu} > \text{CC/cp air/GO}$ .

➤ *Polyethylene (PE) packaging material* antioxidant activity:  $\text{PE/20kGy/EDC+NHS/CHT} < \text{PE/30kGy/EDC+NHS/RO} < \text{PE/cp air/EDC+NHS/CHT} \approx \text{PE/20kGy/EDC+NHS/TT}$  and for antibacterial character:  $\text{PE/20kGy/EDC+NHS/TT} < \text{PE/30kGy/EDC+NHS/RO} \approx \text{PE/20kGy/EDC+NHS/CHT} \approx \text{PE/cp air/EDC+NHS/CHT}$ .

# Dissemination



## Related Projects:

1. **Antimicrobial bionanocomposites for medical applications (BIONANOMED)**  
Contract nr. 164/2012, PNII-PT-PCCA-Tip II UEFISCDI C. Vasile, *project director*;
2. **Bilateral collaboration Romania-Norway “Improving food safety through the development and implementation of active and biodegradable food packaging systems”** EEA-JRP-RO-NO-2013-1-0296 *1SEE/ 2014*, Acronym: **ACTIBIOSAFE**, C. Vasile - *coordinator*.
3. Erasmus+: **Joint innovative training and teaching/learning program in enhancing development and transfer knowledge of application of ionizing - TL-IRMP – coordinator Poland**, Romanian partner coordinator - C. Vasile.

## Patents Applications

1. **Procedure and composition for obtaining new polymeric biocompatible bionanocomposites with antimicrobial and antioxidant properties for medical uses.** R.N. Darie, R. Lipsa, N. Tudorachi, E. Paslaru, C. Vasile, B.S. Munteanu, OSIM A00598/ August 2014;
2. **Procedure and composition for obtaining bioactive (biocompatible and antimicrobial) polyurethane surfaces by electrospinning/electrospraying for medical and pharmaceutical uses.** B.S. Munteanu, E. Paslaru, D. Macocinschi, D. Filip, C. Vasile, OSIM A00651/August 2014.

# Dissemination



## Published papers:

1. **Polylactic acid (PLA)/Silver-NP/VitaminE bionanocomposite electrospun nanofibers with antibacterial and antioxidant activity**, B. S.Munteanu, Z. Aytac, G.M. Pricope, T.Uyar, C. Vasile, *Journal of Nanoparticle Research*, 2014, 16:2643,;
2. **Mechanical behavior at nanoscale of chitosan-coated PE surface**, E. Stoleru (Paslaru), Y. Tsekov, R. Kotsilkova, E. Ivanov, C. Vasile, *Journal of Applied Polymer Science*, 2015, DOI:10.1002/app.42344
3. **Biomass effect on gamma-irradiation behavior of some polypropylene biocomposites**, E. Parparita, T. Zaharescu, R. N. Darie, C. Vasile, *Industrial & Engineering Chemistry Research* 2015, **54**, 2404–2413, DOI:10.1021/ie5043984.

## Book chapters:

1. **Electrospun Nanostructures As Biodegradable Composite Materials For Biomedical Applications**, E. Pâslaru (Stoleru), B. S. Munteanu, C. Vasile, Ed. Dilip Depan, CRC Press, 2015, in *Biodegradable Polymeric Nanocomposites: Advances in Biomedical Applications*; Taylor and Francis-Publisher CRC Press Publishers, U.S.A , 2015;
2. **Surface Functionalization of Cellulose Fibers** by A. Sdrobis - Irimia, C. Vasile in the book: *Cellulose and Cellulose Derivatives: Synthesis, Modification, Nanostructure and Applications*. Ed. Dr. Md. Ibrahim H. Mondal, Nova Science USA, Publ. 2015

# Dissemination



## Communications and posters at international conferences:

1. **Lactoferrin-coated poly(lactic acid)**, E. Pâslaru, G. E. Hitruc, E. G. Ioanid, A. Vesel, G. Pricope, C. Vasile, International Conference "Eco-sustainable Food Packaging Based on Polymer Nanomaterials" COST ACTION FA0904, Rome, Italy, 26-28 February 2014;
2. **Protein nanolayer with antimicrobial and antioxidant properties immobilized onto cold plasma or gamma activated poly(lactic acid) substrate**, E. Stoleru Paslaru, G.E. Hitruc, E.G. Ioanid, T. Zaharescu, A. Coroaba, G. M. Pricope, C. Vasile, 6<sup>th</sup> Szeged International Workshop on Advances in Nanosciences, Szeged, Hungary, 15-18 October 2014;
3. **Method and composition for obtaining stratified composites**, E. Pâslaru, B.S. Munteanu, R.P. Dumitriu, C. Vasile, The 7<sup>th</sup> Edition of "European Exhibition of Creativity and Innovation" - EUROINVENT 2015, Iasi, Romania, 14-16 May 2015 gold medal.
4. **Textile fibers responsive to temperature and pH changes**, A. Sdrobis, E.G. Ioanid, C. Vasile, The 7<sup>th</sup> Edition of "European Exhibition of Creativity and Innovation" - EUROINVENT 2015, Iasi, Romania, 14-16 May 2015 gold medal.
5. **Effect of gamma irradiation on cellulose-based materials**, A. Irimia, T. Zaharescu, F. Doroftei, A. Coroabă, C. Vasile, COST Action FP 1205, March 10-11, 2015, Iasi, Romania.
6. **Fibre celulozice cu proprietati antimicrobiene si antioxidante**, A. Irimia, E. Csiszar, G.E. Ioanid, T. Zaharescu, C. Vasile, Congresul Internațional din Cadrul Zilelor Universității „Apollonia”, 26 februarie - 1 martie 2015, Iași, România.