

*Conferenze*

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# Novel Etheroatom Containing Aliphatic Polyesters for Biomedical and Environmental Applications

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## ABSTRACT

Negli ultimi anni, i polimeri biodegradabili hanno attratto sempre maggior interesse, soprattutto in settori quale quello biomedicale o ambientale, nei quali la vita utile del materiale è breve e il suo smaltimento deve avvenire senza conseguenze per l'habitat in cui viene rilasciato. In questi ambiti, i poliesteri alifatici rappresentano senza dubbio una delle classi polimeriche più adatte e studiate, perché abbinano a costi delle materie prime e di produzione relativamente contenuti, interessanti proprietà meccaniche, oltre che offrire garanzia di biodegradabilità e biocompatibilità.[1]

Tra i vari poliesteri alifatici, il poli(butilene succinato) (PBS) ed il poli(butilene cicloesandicarbossilato) (PBCE), pur essendo meno noti rispetto al poli(acido lattico), al poli (acido glicolico) e al poli( $\epsilon$ -caprolattone), hanno attirato l'attenzione del mondo scientifico ed industriale. Entrambi possiedono ottime proprietà termiche, ma mostrano caratteristiche meccaniche che non soddisfano i requisiti di impieghi in cui è richiesta una elevata flessibilità di catena e, in aggiunta, presentano tempi di degradazione piuttosto lunghi a causa della loro elevata cristallinità.

A tale scopo, il presente contributo illustra i principali risultati ottenuti inserendo lungo la catena polimerica di PBS e PBCE atomi di ossigeno etero e di zolfo, allo scopo di ottenere materiali con proprietà più mirate per alcune applicazioni specifiche.

Sono stati così ottenuti, tramite policondensazione e miscelazione reattiva, nuovi poliesteri e copoliesteri contenenti eteroatomi, le cui proprietà chimico/fisiche e meccaniche sono state approfonditamente studiate. I risultati ottenuti sono stati oltremodo incoraggianti; agendo infatti sulla composizione chimica e sull'architettura molecolare, è stato possibile modulare sia l'idrofilicità superficiale sia la velocità di cristallizzazione e la quantità di fase cristallina, fattori che impattano notevolmente sulle proprietà meccaniche e sulla velocità di biodegradazione sia idrolitica che enzimatica.[2]

Infine, tramite studi più specifici quali la realizzazione di costrutti tridimensionali o l'analisi della biocompatibilità da un lato, e la verifica delle proprietà barriera dall'altro, è stato possibile dimostrare la grande versatilità di tali polimeri, che possono essere indifferentemente impiegati sia in campo biomedicale sia ambientale.[3,4]

## References

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## *E-Beam Crosslinked Polymeric and Bio-Hybrid Nanocarriers for Drug Delivery and Bioimaging*

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The interest in nanotech applications for medicine is constantly growing as it holds the promise of radical improvements of current therapies and diagnostic modalities. Several nanocarriers have been proposed in the literature, some of them have demonstrated highly successful in the application and are now being evaluated in clinical trials. However, the road to the market is still long and difficult for several reasons. Indeed, despite of some success cases, a huge gap between the in vitro properties and the in vivo behavior of such nanocarriers has been observed. Another limitation still present in the field of Nanotechnology applied to Medicine is the lack of “simple” and “clean” manufacturing processes, that are simultaneously viable at industrial level and able to grant high control over the product properties.

Newer promising nanocarriers have been developed in more recent times, which include nanogels. These nanoparticles have demonstrated excellent potential for systemic drug delivery and for the design of multifunctional nanocarriers (e.g., theranostics) and triggered drug-release nanodevices.

In the present work, a very promising approach, based on e-beam radiation-induced radical crosslinking of a water soluble, biocompatible synthetic polymer has been developed for the generation of Poly-N-(Vinyl-Pyrrolidone) (PVP)-based nanocarriers, i.e. nanogels with a base PVP structure. In particular, correlations between process and material properties have been established through a detailed products analysis in order to obtain materials with tailored physico-chemical properties (particles size distribution, surface charge density) and multifunctionality. More in detail, the generated nanoparticles have been characterized through different techniques, such as dynamic and static light scattering, photo-correlation spectroscopy, FT-IR, Raman, solid state NMR and XPS spectroscopies, SEM and AFM. PVP-based nanogels have been then used as building blocks for the assembly of tumor-target “composite” nanodevices. “Model” ligands with various biological functions and drugs have been conjugated to the nanogels. Moreover, the biocompatibility and localization pattern of the nanocarriers in cell cultures have been evaluated.

E-beam irradiation using industrial type accelerators has demonstrated to be a viable manufacturing process for nanogels generation, since it grants high yields in terms of recovered product and high throughputs. Moreover, through a proper selection of the experimental parameters, this approach has allowed to obtain NGs with the desired properties, in terms of size, surface charge density, degree of crosslinking and functionality. Furthermore, it has been demonstrated that all the NGs produced are biocompatible and able to be internalized by cells owing to: (i) their chemical structure, that closely resembles that of PVP; (ii) the physico-chemical properties imposed by the synthetic approach, i.e. their controlled size at the nanoscale and favorable surface properties. Finally, the many functional groups grafted on the NGs are available for coupling reactions with bioactive molecules, such as targeting moieties, drugs and metal-ions

chelating agents.

All the evidences collected in this study, in terms of favorable properties-by-process features of the generated nanostructures and inherent advantages in the manufacturing process developed, can represent the fundamentals for the development of a “radiation-engineered nanocarrier platform” for diagnosis and treatment of various diseases, and cancer in particular.

# Novel Photopolymers and Innovative Technologies for the Fabrication of Microfluidic Devices

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## ABSTRACT

In this work we developed novel UV curable polymers suitable for the fabrication of microfluidic devices via innovative methodologies based on photopolymerization.

**Keywords:** Microfluidics, photopolymerization, photolithography.

Microfluidic devices can process and manipulate small amounts of fluids (nanoliters), using channels with a diameter of tens to hundreds of micrometers. One can effectively scale down chemical and analytical reactions to a microscopic size, reduce the quantities of reagents involved, increase the selectivity, efficiency and speed of the process, and minimize the involved costs. Therefore microfluidics represents an emerging technology in many areas of chemistry and biotechnology [1]. The aim of this work was to explore and synthesize new polymers with properties suitable for specific microfluidic applications and to develop rapid and low cost microfabrication technologies. Different monomer structures were studied: perfluoropolyethers (PFPEs), poly(ethylene glycols), and polysiloxane monomers.

This talk will focus on methacrylic perfluoropolyethers. PFPEs are highly fluorinated polymers with good thermal resistance, low surface energy, low refractive index [2,3] and outstanding chemical resistance. They are therefore suitable for the fabrication of microfluidic devices, especially for chemical applications [4]. We developed a simple photolithographic approach to transfer micropatterns into photocurable PFPE, which is directly photopolymerized in presence of a mask. The pattern transfer is highly controllable: we patterned with high fidelity structures having high density, high aspect ratio and complex shapes useful for microfluidics. Moreover we obtained a complete device (Figure 1) closing the microfluidic structures by a simple bonding procedure based on partial UV curing. Finally we successfully tested the PFPE microfluidic devices for the benzopinacol formation via photoreduction of benzophenone in isopropanol [5], selected as model reaction. We demonstrated the functionality of solvent-resistant PFPE devices and we showed that they have a promising potential for application in microfluidic organic synthesis.

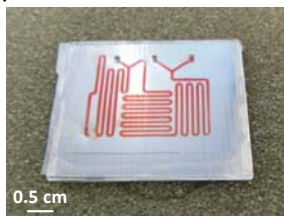


Figure 1: PFPE microfluidic device.

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