STUDIO D'INGEGNERIA ROGANTE
ROGANTE ENGINEERING

Neutron techniques for the advanced characterization of invasive cardiovascular devices

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Member of the BIONECA CA16122 since June 2017
Participating in the BIONECA WG1, WG2, WG5

Expertise in:

- **Advanced characterization by Neutron Techniques of industrial materials and parts, including invasive medical devices**
- **Materials processing**
- **Mechanical and Nuclear Engineering**
- **Decommissioning of Nuclear Facilities and Nuclear Installations**
- **Feasibility analyses**
- **Technology transfer**

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Landmark for Industrial Applications of Neutron Techniques (*Applicazioni Industriali delle Tecniche Neutroniche*®), with the following main activities:

- Pioneering applied research activities related to advanced characterization of industrial materials and components
- Supporting Industry in the choice of methodological approaches and solution of different technical issues related to quality and characterization
- Organizing and co-organizing events (Conferences, Workshops, Seminars) (e.g., MED in Ireland, MATRIB and MTSM in Croatia) in which REO presents Industrial Applications of Neutron Techniques

Some examples:

Advanced characterization of invasive cardiovascular devices

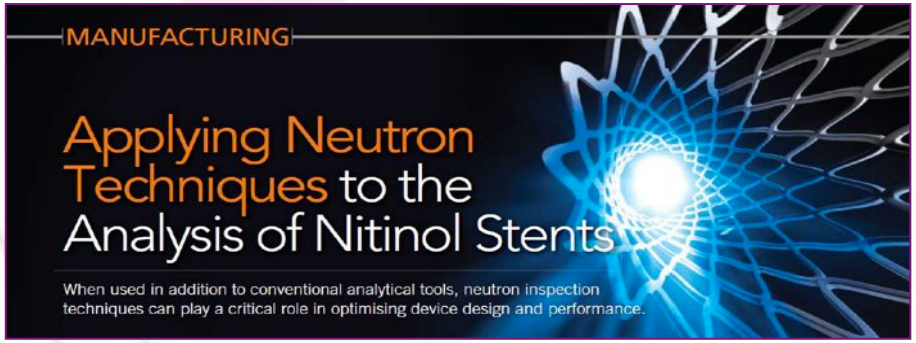
Several invasive cardiovascular devices, once implanted entirely or partially in the human body, are programmed to remain there for the whole patient's life.

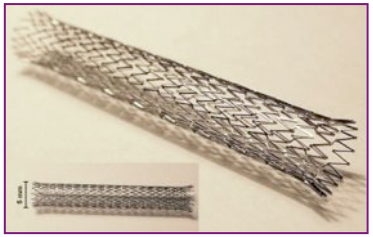
As a result, they are subjected to all the insults that the biological environment can cause, such as the **ionic environment of the blood** and the **substances and cells that secrete**, as well as other **aging factors**.

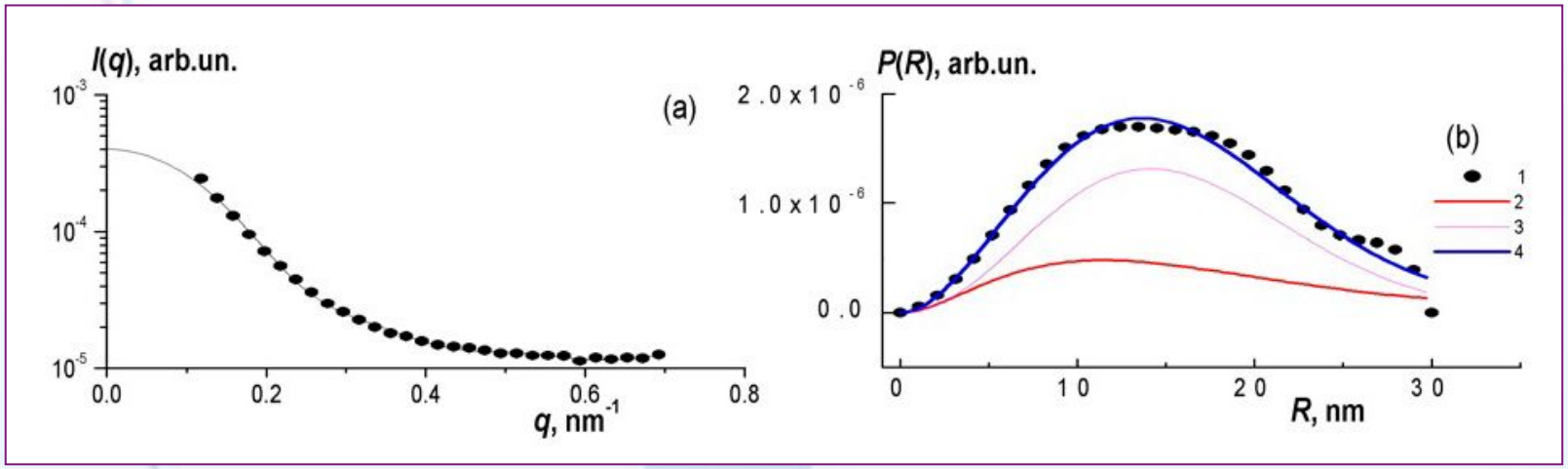
The progress of such devices directly depends on the application of effective methods for their characterization to assess their damage by aging, in order to establish the correct relationship between the characteristics of defects and functional macroscopic properties.

Advanced characterization of invasive cardiovascular devices, and in particular at the level of micro- and nano-scale, by means of neutron techniques, could be very helpful.

Such advanced characterization is aimed to facilitate improving existing materials and devices and producing original and innovative parts also for different types of applications, with optimization of quality, functionality and performance.





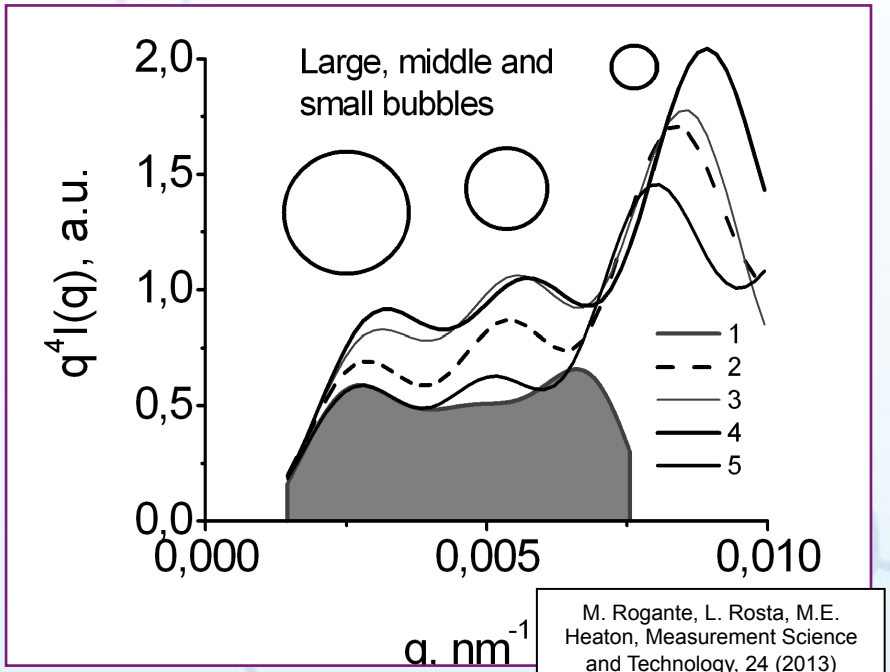


Nano-structural characterization of Nitinol stents

Neutron investigation of medical polyurethanes 1/2

A current research is devoted to create flexible implants with improved characteristics based on polyurethanes with island plasma coating. **Problem:** Fracture of stiff solid coating may happen, due to the mechanical load of the treated polymer

Important target: progress and analysis of both soft polymers and their surface's coatings resistant to definite loads, with improved biomedical qualities as compared to the uncoated material. **Structural analyses at the micro- and nano-scale.**



M. Rogante, L. Rosta, M.E. Heaton, Measurement Science and Technology, 24 (2013) 105601.

Small Angle Neutron Scattering (SANS) analysis of polyurethanes samples (mono-ethylene-glycol based)

Results:

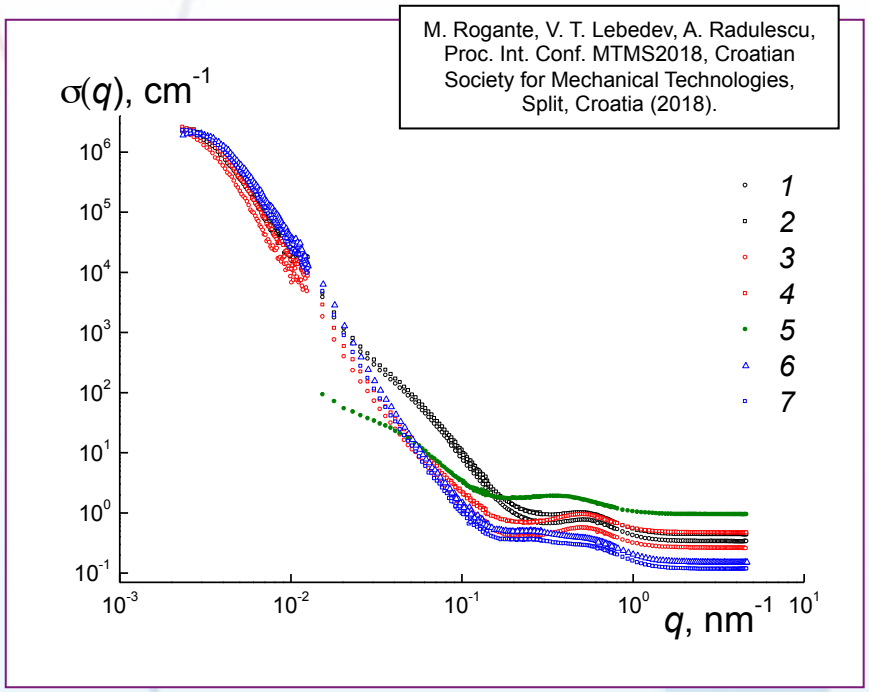
Presence of different fractions

Total area of fraction vs. bubble's radius Variation in chemical composition and technology of polymers → bubbles' radii change

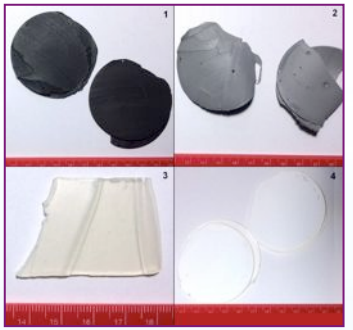
The small fractions dominate giving a large contribution to the interface area

→ These kind of results help to control and predict the functional properties of polymers, which strongly depend on size and amount of defects and especially on their total area detected by SANS

Neutron investigation of medical polyurethanes 2/2



Nano-structural analysis of polyurethanes samples (mono-ethylene-glycol based)



Sample No	r_{g1}, nm	r_{g2}, nm
1, left	2.56 ±0.01	52.43 ±0.02
1, right	2.71 ±0.01	52.54 ±0.02
2, left	2.27±0.01	61.92 ±0.02
2, right	2.25±0.01	62.87 ±0.02
3	2.56±0.01	56.98 ±0.10
4, left	2.77±0.01	62.53 ±0.01
4, right	2.67±0.01	61.72 ±0.02

Gyration radii of small and middle-sized structures in the samples 1-4.

Other Applications of Neutron Techniques:

a) medical-grade thermoplastic polymers, in particular:

- polyester
- polyether
- polycarbonate materials.

These are among the key polymers used in vascular catheter and central venous catheter applications.

Data can be applied to improving material properties or increasing precision in the control and prediction of functional properties, which strongly depend on size and amount of **defects** and especially on their total area as detected by SANS.

b) various other mechanical devices used in interventional and surgical areas as well as catheter technologies, including ballooning with different materials, sizes, and diameters.