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The Application of Small Angle X-Ray Scattering in Drug Composite Studies

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Editorial

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Abstract

This brief work comments on SAXS as a potential technique to be applied to Drug Delivery Systems.

Keywords: SAXS; DDS; Nanomedicine; Nanocomposite

Abbreviations: DDS: Drug Delivery Systems; FTIR: Fourier Transform Infrared; XRD: X-Ray Diffraction; TGA: Thermal Gravimetric Analysis; DSC: Differential Scanning Calorimetry; HME: Hot Melt Extrusion; SAXS Small Angle X-ray Scattering.

Introduction

Nanomedicine implies the use of nanotechnology applied to medicine. Drug delivery systems (DDS) represent a promising improvement of drug administration and have been extensively studied in the last decades. The DDS consists of a drug-loaded carrier that protects the drug during its administration and must be able to release the drug in a sustained manner, as well as being degraded after its use. Furthermore, the drug administration through a DDS limits the patient's side effects because it can be targeted to a special environment, and it releases the drug continuously without peaks of concentration. The drug carriers include biomaterials such as liposomes, nanospheres, hydrogels, and polymers, among others.

The physico-chemical properties of the carriers, as well as the DDS, must be deeply investigated to understand how they work so they can be improved, and be produced in large-scale as well as in personalized medicine.

Interdisciplinary studies are crucial for the development of well succeeded DDS. This includes expanded studies of the drug carriers and nanocomposites properties associated with their application *(in vitro* and *in vivo*).

There are several consolidated techniques that should be applied to understand the carriers and nanocomposites behavior such as Fourier transform infrared (FTIR), Raman spectroscopy, X-Ray Diffraction (XRD), Thermal Gravimetric analysis (TGA) and Differential Scanning Calorimetry (DSC).

It is important to notice that the production method of the DDS may significantly alter the properties of both the carrier and the drug. DDS of drugs and biopolymers as polycaprolactone (PCL) and polylactic acid (PLA) may be produced by Hot Melt Extrusion (HME), 3D printing, solvent casting, etc. Each method generates a DDS with specific features that can be elucidated by their advanced characterization.

Small angle X-ray scattering (SAXS) is a non-destructive, powerful technique that provides relevant statistical results compared to microscopy. Most of the literature shows synchrotron SAXS analyses, but there are bench-scale equipments that provide very satisfactory results. Although SAXS is usually described as a complementary technique

to other characterization methods such as microscopy, it is decisive and occasionally the only method to obtain specific results. De Jesus Junior, et al. [1] produced filaments of PCL and atorvastatin by hot melt extrusion (HME). The most conventional characterization techniques such as XRD were unable to observe the drug in the composite due to an amorphization caused by the production method (HME). Since atorvastatin has a peak in the SAXS region, it was possible to observe the drug in the DDS by this technique employing a bench-scale equipment. While XRD is applied for crystalline materials, SAXS can be used for both amorphous and crystalline materials, as the observed scattering is a result of the difference in electronic density of the analyzed materials.

Li, et al. [2] contributed with an extensive review on the use of SAXS for studies of nanoparticles in general, while Sakuragi [3] focused on the evaluation of the structure of drug carries by Synchrotron SAXS. There are other reviews on the use of SAXS for specific applications such as biomaterials [4]; catalysts [5] and batteries [6].

Finally, a wide range of materials can be analyzed by SAXS as colloidal suspensions, gels, solids, and powder. SAXS is interesting because can observe few to hundreds of nanometers, which is comparable to the scale of DDS components. This technique investigates the structure and conformation of biomaterials, inter-particles interaction and changes in the drug or carrier after the DDS fabrication.

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