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A review on approaches to bio distribution studies about gold and silver engineered nanoparticles by inductively coupled plasma mass spectrometry ☆

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ABSTRACT

This paper gives a general overview about bio distribution studies which are especially related to engineered nanoparticles (NPs) made of gold and silver. The analysis of biological materials from bio distribution studies plays a significant role in the application of atomic spectrometry to study NPs. Therefore, special focus is given to the generally applied strategy as well as the use of the inductively coupled plasma mass spectrometry (ICP-MS) technique for the determination of the NPs containing metals. An overview of the recent research applications on gold and silver NPs is also presented. While for gold NPs a large variety of very different sizes, shape and coating are known, they also provide many opportunities in imaging, diagnostics, and therapies of nanomedicine. Hence, their bio kinetics in the body are prerequisites for specific tailoring of nanomedicinal applications and for a comprehensive risk assessment. Silver NPs are applied in a lot of consumer products; therefore it is useful to get a better understanding of their in vivo distribution.

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1. Introduction

Nano-objects are defined as materials with at least one dimension in the nanoscale range below 100 nm. Furthermore, the nano-objects are distinguished into NPs with three, nanofibres with two and nanoplates with one dimension in the nanoscale range (<100 nm) [1]. Fig. 1 shows an overview of the latest ISO definitions [2]. As long as NPs show physical and chemical properties, their special and unusual properties have opened countless applications in medicine, industry and other applications [3–6]. Engineered NPs promise innovation in various fields of application and with high prospects for new fields [7]. As the range of gold NP types and their applications continues to increase, human safety concerns are gaining attention, which makes it necessary for better understanding the potential toxicity hazards of these novel materials. Due to its anti-microbial function, nanosized silver is applied to textiles [8], paints [9] or for several medical applications [10] such as implant coatings [9]. The conductivity properties of nanosilver make it also interesting for electronic applications such as brazing and soldering [11].

On the other side, the widespread applications of NPs are suspected to cause mostly unknown consequences to human health and also to the environment. Therefore, much research is being conducted recently in toxicology of engineered NPs [12–15], which often includes bio distribution studies.

Nanoparticle toxicity is still an issue in the latest WEF Global Risk Report 2010 [16]. Some countries developed special evaluation tools for risk prioritisation. Some of these control banding tools focus on the evaluation of the emission potential, others on risk banding and potential exposure [2]. While still much is required to be studied, several toxicological effects are already known from different studies on engineered NPs [4,17–20].

2. General approach for in vivo bio distribution studies of gold and silver NPs

The general approach for in vivo bio distribution studies of NPs can be divided into seven steps (a through g) which are summarized in Fig. 2 and described in more detail as follows.

a) Preparation of the study aim in cooperation with toxicologists and experienced staff for in vivo studies (see also g)
The type and the kinetics of bio distribution can be determined at cellular and organism levels. There are differences in biocompatibility, bio distribution, biodegradation, inflammation and interference with cells and normal functioning of organs will determine the toxicity of engineered NPs. The bio distribution of NPs has been studied in mice, rat, swine and in human immune cells; however, very seldom in humans itself [2,21]. Relevant is the way of administration while generally intravenous injection is applied. Special studies are dealing with the inhalation or dermal application or ingestion of NPs. The type of particle administration, the time of examination and the selection of the organs of interest are relevant for the toxicological interpretation of the analytical

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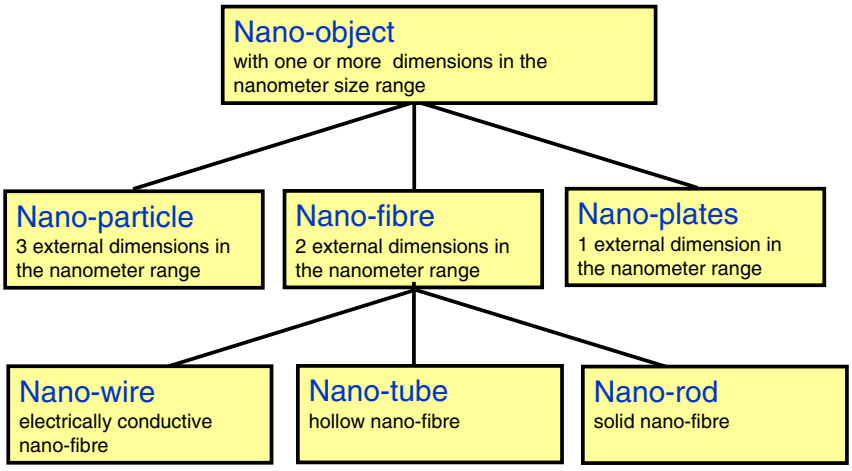

Fig. 1. Definition of nano-objects, nanoparticles, nano-fibres and nano-plates according to ISO/TS 27687 (nanoscale = size range from approximately 1 to 100 nm); reprinted with permission from [2].

results. It is remarkable that a lot of characteristics of NPs must be considered very closely before using a certain type of NPs for bio distribution studies; see b).

b) Selection and characterization of the NPs which should be used for the in vivo studies

Prior to the use of engineered NPs within bio distribution studies their general characterization is necessary because different NPs show different distributions and all possibly relevant aspects are shown to be known before. Table 1 gives a general overview about the most important analytical techniques which are applied for the characterization of NPs.

These must be selected and chemical composition, solubility,

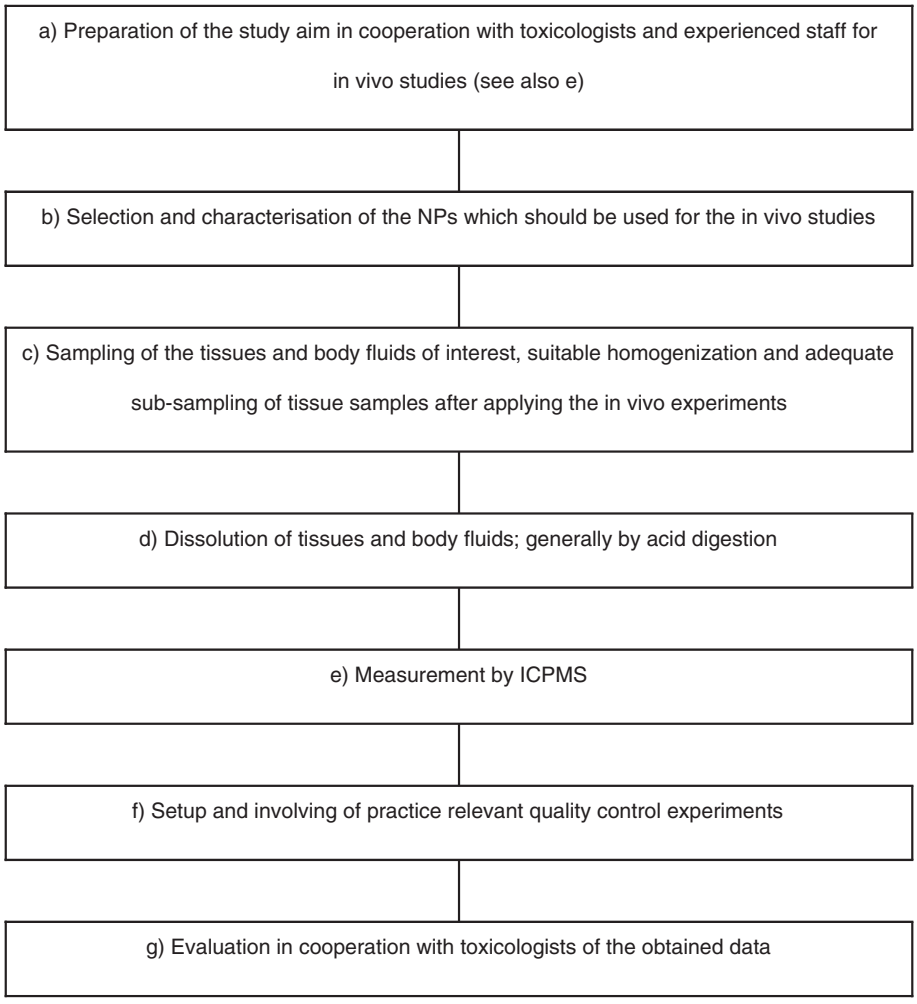

Fig. 2. Overview about the general approach of biodistribution studies on silver or gold nanoparticles.

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