

Health and environmental safety of nanomaterials

Polymer nanocomposites
and other materials
containing nanoparticles

Edited by James Njuguna, Krzysztof Pielichowski
and Huijun Zhu

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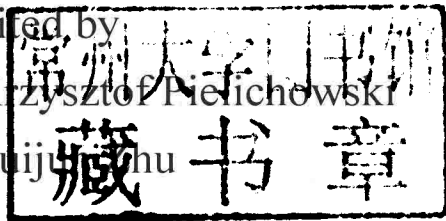
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This book focuses on environmental and health issues associated with the development of nanocomposites, particularly potentially harmful exposure to raw nanomaterials and their variants at different stages of a product life cycle. Applications of nanomaterials can be traced back to ancient times when clays, which contain layered silicates (now considered to be nanomaterials), were used in feed for farm animals to promote growth and health, and as a supplement to treat gastrointestinal disorders. It is only in the last two decades that man-made nanomaterials have become available for potential applications in areas covering almost every aspect of human life. Alongside the explosive development in nanomaterial applications are growing concerns about the impact of nanomaterials on the environment and human health. A group of scientists who are at the forefront of nanomaterial development and application in such areas as automotive technology, chemistry, ecotoxicology, and human health address these concerns in this book.

With the rapid development of nanotechnologies, the safety of nanomaterials is of crucial importance and must be fully appreciated and understood. Processes at nanoscale between the molecular and supramolecular levels leads to novel material properties, more efficient utilization of precious raw materials, and smarter and low-energy consumer products and devices. However, as with any new technology/material, many of the health and environmental effects are still unknown and scientific uncertainties about the safety of nanomaterials do exist. It is generally agreed that small size means easy access to living organisms via inhalation or trans-dermally and hence may lead to increased risks to various living systems. Once in the body, nanoparticles may have the ability to translocate and be distributed to different organs, including the central nervous system. Factors such as chemical reactivity, surface characteristics, and ability to bind to body proteins are considered to govern the behaviour of nanoparticles in living organisms.

The first part of the book introduces the reader to the types and properties of nanomaterials, nanofillers, and nanocomposites. To understand the impact of engineered nanoparticles on human health and the environment, extensive

nanoparticle physicochemical characterization is needed and a sufficient amount must be sampled for toxicological investigations. In relation to toxicological studies, investigation of all physical and chemical parameters would be ideal, but the workload would be immense. Nevertheless, it is now recognized that in order to build nanomaterial-based products that are safer by design, and to propagate best practice in nanosafety assessment, it is vital to bridge the current gap between nanotechnology developments and nanosafety assessment. This is important in developing a better understanding of the mechanisms of toxicity, which are also addressed in Part I. This is particularly important with regards to the research infrastructures involved in the production of nanomaterials. One crucial stage is to remove, control, and improve the stability of the quality of various types of engineered nanomaterials produced for commercial purposes such as consumer products or downstream industrial applications.

Part II deals with the release and exposure of nanomaterials. Critical issues include developing a fuller understanding of the different characteristics of engineered nanomaterials, and those characteristics that may cause harmful effects to living organisms at molecular, cellular, organ, and whole-organism levels. Obviously, before any effects can occur, exposure to engineered nanomaterials is necessary, and an understanding is required of the associations between the dose of engineered nanomaterials and its effects on organisms. The main methods for nanoparticle exposure assessment, sampling techniques, and data analysis are discussed. Next, the sampling protocols for the safety testing of polymer materials are addressed. This is followed by a detailed discussion on measurement and sampling techniques for characterization of airborne nanoparticles released from nano-enhanced products. This part of the book concludes with life cycle assessment of engineered nanomaterials.

Part III addresses the safety of selected types of nanomaterials. First, clay minerals, known to humans from prehistoric times, are reviewed. The potential toxicological and ecotoxicological risks of carbon nanotubes are then discussed. Metal oxide nanomaterials are widely used but their health and environmental effects still need to be studied in detail. The health and environmental risks of nanomaterials in the case of fire are also of primary importance. Although the use of nanoparticles yields enhanced flame retardancy in polymer nanomaterials due to char layer formation, the labyrinth effect and molecular mobility depression, free nanoparticles (dry, dispersible single particles or agglomerates) may enter the gaseous phase during combustion and eventually enter the body through inhalation. Finally, the thermal degradation, flammability, and toxicity of polymer nanocomposites are discussed.

We hope this book will be a useful tool for scientists, academics, research scholars, polymer engineers, and those working in industries using nanomaterials. The book will also be useful to undergraduate and postgraduate students and hopefully an inspiration to young scientists to investigate the safety of nanomaterials in more detail. The editors acknowledge the FP7 project

(No. 228536-2) entitled 'Nanomaterials related environmental pollution and health hazards throughout their life cycle (NEPHH)' funded by the European Commission Framework 7, which provides an overview of the potential hazards of nanomaterials for laboratory workers (mainly in nanocomposites manufacturing and processing) and measures that can be taken to minimize workplace exposure and associated risks. We also thank all the contributors to this book and the team at Woodhead Publishing for their excellent editorial support.

James Njuguna
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Huijun Zhu

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