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Ecomaterials research and development activities in China

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Abstract

A brief review of the recent advances in the field of ecomaterials in China is presented, giving opinions on the current activities and suggesting possible future courses of action. The past 10 years has seen the development of the concept of ecomaterials involving practical research and development of environmentally conscious materials, and the establishment of related systems including national programs and laws. It has been an important period for the development of materials science and the goal of creating a sustainable society in China. It has now become clear that ecomaterials, which exhibit high performance whilst being environmentally benign in their life cycle, are evolving from being only materials for end-of-pipe applications to include all materials being designed on the basis of life-cycle thinking.

Keywords: Ecomaterials; Life cycle assessment; Hazard-free; Green-processing; Higher-efficiency; Recyclable

1. Introduction

Materials are one of the basic founding blocks for the development of society and economy. For the production, manufacture, application, and disposal of materials, numerous energy and resources are consumed, and environment deterioration occurs as a result. To harmonize materials development with environmental protection, sustainable developmental ecomaterials or environmentally conscious materials, have been actively sought in recent years throughout the world [*1,2,**3]. The main activities and schedules related to ecomaterials research and development in China are briefly introduced in this article.

In view of the extremely rapid industrial development in China, there is a great danger that mistakes made in the past by the West may be repeated in China. China is a large materials producer as well as a user [*4]. The principal Chinese raw materials output, including iron and steel, non-ferrous metals, cement, coal, glass and so on have been largest in the world over recent years. At the same time, the energy and resource consumption required is sharply increasing, much higher than the world average for GNP basis. This aggravates the resource and energy shortage and causes serious environmental pollution and ecological deterioration. Ecomaterials are not only in demand due to advanced materials development but also for materials industry by the global environment, social development, and human existence.

In recent years, research into ecomaterials has progressed in the fields of metallurgy, metals, non-metals, polymers, wood, and minerals, amongst others. Functional materials for environmental protection, energy-saving materials, materials supporting low-emission systems, and materials designed by means of LCA and selected for their lower environmental impact are the most important areas to concentrate research on when addressing the global environmental problems caused by materials technology. Since all countries see environmental measures as an important strategy to protect their own industry, ecomaterial and ecoproducts developed with related technologies have not only become the popular topics for the basic research, but also one of the most vehement trade strategies in the market competition. Research on ecomaterials has led to the development of new methods for the design of materials which have much lower environment loads in their life cycles and can be used to replace other higher impact

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materials. Also the ecomaterials learning, to be used as a new concept of materials, still is in the initial stage of the development, and its science is still in infancy. Moreover additional efforts are still needed for the ecomaterial learning, on the publicity and education, and lawmaking or evaluation standard etc.

2. Development of ecomaterials concept and evaluation method

Ecomaterials as a new material concept have gained considerable worldwide attention over decades. It endued materials with the attribute of environmental consciousness. In the early stage, only thinking of the material's function characteristics to solve environmental problem was considered. In the last decade ecomaterials activities included the concept's development, design with ecosystem, and life cycle analysis emphasizing all the materials including the construction material and every kind of functional material with environmental attribute. For example, how to satisfy a function while lowering the environment load, and how to improve the material's recycling, or how to use minimal amount of material are the key to ecomaterials. Environmentally conscious materials are evolving from materials for end-of-pipe application to all materials designed by taking into account life cycle thinking over the whole life cycle. Many research actvities on ecomaterials bring up new lessons in material science and engineering technique. Ecomaterials learning involve the production, use, disposal, recovery and each link, and is a multi-disciplinary matter that crosses over material science, environment science, biology, etc., with complicacy of systems engineering. Standpoint that developed for more than 10 years is widely accepted for materials worker to think as: ecomaterials should be at the same time to have satisfied usage function with the material of the coordination of good environment. According to the relevant research report for main characteristics, from material kinds, ecomaterials should be: (1) No poisonous and harmless, including chemical stability, biological safety, avoiding green house effect and ozone layer depletion effect etc. (2) Lower consumption of energy and resources over the whole life cycle. (3) Recyclable, reusable and easy recovery. (4) Higher use efficiency with structural dependability. (5) Reduce pollution to protect and purify environment, and also include detecting pollutants.

For environmentally conscious synthesis and processing (also call the green processing), according to its characteristics, is emphasized on four aspects: energy saving, resources saving, zero emission or lower pollution technology, and technology for environmental decontamination.

2.1. Research on materials life cycle assessment and materials flow analysis

Life Cycle Assessment (LCA) is a technique for systematically analyzing a target from cradle-to-grave, that is, from resource extraction through manufacture and use to disposal. It is an important constituent of ISO14000 series. It is an effective tool that not only gives a detailed information of environmental profiles of a material, product or a process, but also its results are significantly useful for the purpose to improve the utilization efficiency of resource and energy and decrease environmental impact, as the basis of design for environment (DFE).

Material Life Cycle Assessment (MLCA) is discussed and the research is emphasized in China [5–8]. From 1998, supported by the National High-Tech. R&D (863) Program of the Ninth Five-year Plan (1996–2000), the project Research On Materials Life Cycle Assessment was put in practice to develop practical MLCA methods primarily with some typical materials and processes, including steel and iron, aluminum, cement, etc. [**9,*10,11]. From 2001, the follow-up project Materials Life Cycle Assessment and Its Application has been supported by the 863 Program of Tenth Five-year Plan (2001–2005). Focusing on the research of advanced materials compatible with environment, to accumulate the abundant environmental load data about energy source, resource and wastes emissions, the measurement of environmental impact (combined with typical materials) is researched [**12]. Based on this data, the data model and database framework of MLCA is systematically studied. The basic framework mainly includes system framework, LCA methodology, energy consumption, resource input, and inventory; finally, the MLCA databases for several typical materials have been built in term of this framework [13]. At the same time, MLCA software about the data management and LCA evaluation is under development.

Also a key research project has been supported by BNSF on Materials Flow Analysis (MFA) and Database in Beijing. It is analyzed by means of MFA that utilization efficiencies of natural resources and energy, the discharge of waste, and the technical economical indices of metallurgical industry, chemical industry, building materials industry and petrochemical industry, which form the main body of material industry of Beijing region [**12].

3. R&D of ecomaterials and related technology

The research of ecomaterials in China started in the beginning of the 1990s. Many efforts from universities, industries, and national laboratories have been made on this topic, together with the guidance and support of the