ADVANCES IN MATERIALS SCIENCE RESEARCH

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## VOLUME 17

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nova publishers
New York

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Web Site: http://www.novapublishers.com



**Library of Congress Cataloging-in-Publication Data**

ISSN: 2159-1997

ISBN: 978-1-62948-735-9 (eBook)

*Published by Nova Science Publishers, Inc. † New York*

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# PREFACE

Materials science encompasses four classes of materials, the study of each of which may be considered a separate field: metals, ceramics, polymers and composites. This volume gathers important research from around the globe in this dynamic field including research on the outstanding contributions in the area of polymeric micro and nanoparticles as drug delivery systems; strategies to modify the inorganic clays and to make them compatible with polymeric matrices and the effect of each one; present problems of ceramic lubricating materials, and the design principle of these materials; the study of Pincina alginite and its applications; the methods of determining the composition of polarons with different mobility and their main magnetic, relaxation and dynamics parameters from effective EPR spectra and the development of glass fibre reinforced polyester composites.

Chapter 1 – There are many disadvantages associated with the use of certain drugs. These are distributed in the organism according to their physical properties such as solubility, partition coefficient and charge. In consequence, drugs can reach a variety of sites where they are outside of their therapeutic range, where they are inactive, or where their action is unwanted or harmful and therefore with negative side effects. Therefore, therapeutically effective and patient-compliant drug delivery systems continuously lead researchers to design novel tools and strategies. Polymeric micro and nanoparticles are micron and submicron size entities made from a wide variety of polymers. Because of their potential ability to improve current disease therapies these micro and nanodevices are being extensively used as drug carriers and controlled release systems in the field of medicine and pharmacy. Indeed, active pharmaceutical ingredients can be encapsulated, covalently attached, or adsorbed onto such carriers. Since all the novel possibilities offered by such devices many methods have been developed in order to prepare micro and nanoparticles, these methods depends almost exclusively on the polymer and the drug employed. In addition, drug loading and drug release mechanisms from these particulate carriers and its biodistribution in the human organism have attracted the attention of the researchers. Among all the approaches proposed in the last years in this scenario, this chapter presents the most outstanding contributions in the area of polymeric micro and nanoparticles as drug delivery systems.

Chapter 2 – Polymer/clay nanotechnology age started with Toyota's work about clay particles exfoliation in nylon-6, by the last 80's and the beginnings of the 90s. The improvements on several properties of the polymeric matrices have been improved by the addition of nanometric scale particles. The most used nanoparticles to reinforce polymeric materials are layered silicates. Their crystalline net consists of bi-dimensional layers where a central octahedral layer of either alumina or magnesia is joined to two external tetrahedrons of silica in such a way that the oxygen ions of the octahedral layer also belong to the tetrahedral layers. In order to obtain the best properties, the key point is the dispersion of the clay particles inside the polymeric matrix but the tendency of the particles to agglomerate is difficult to overcome. In addition, most of the polymers are hydrophilic and original clays are hydrophilic. In order to make them (matrix and clay) more compatible, some chemical treatment will be required. Although there are different ways to optimize the polymer/clay compatibility, the most popular method consists on converting these hydrophilic silicates to organophilic ones by performing chemical treatments of the clay.

In this chapter several strategies to modify the inorganic clays and to make them more compatible with polymeric matrices are studied and the effect of each one, together with the relevant parameters, is established.

Chapter 3 – With the rapid development of modern technology, various machineries have proposed changes in lubricating materials. These are geared toward improving the property of materials and allowing them to surmount severe challenges under extreme conditions (e.g., high/low temperature, special media, atmosphere, etc.) in the fields of aviation, space, nuclear energy, microelectronics, and so on. The ceramic lubricating material is a new solid lubricating material composed mainly of a ceramic matrix, reinforcing phase and solid lubricant. This ceramic lubricating material shows good performance in high temperature and corrosion resistance due to its ceramic-skeleton. Moreover, the ceramic lubricating composite is the only material that can work above 1,000°C, while maintaining low density and excellent corrosion resistance. These materials are considered to be high temperature lubricating technology with the most development potential and practical value. This chapter has analyzed the research focus and present problems of ceramic lubricating materials, and then proposed the design principle of these materials. The design, preparation and performance of several typical ceramic lubricating materials were introduced. Based on these studies, the authors developed a kind of ceramic lubricating composite which has low wear, high reliability and long life, and provide theoretical guidance and technology support for the application of new ceramic materials in the fields of high technology.

Chapter 4 – The study of the natural resources necessary for their rational, efficient and "intelligent" use. This is one of the most pressing issues of our time. Ore and non-ore potential of the Slovak Republic is restricted by the size of its area. Each successful result of geological research uncovering modest raw material supplies is considered to be worthy. Since 1990 the alginite bed situated in Lučenec Valley, locality of Pincina village, has been considered in the above mentioned sense. Alginite represents a rock with relatively high organic matter content which was sedimenting together with the clays in post - volcanic outbursts during geological periods appropriate for algae occurrence. Alginite has a wide variety of utilization as an ecological raw material. Natural character, absence of phytotoxicity, effective economy of mining technology and ecologization of farming systems, those are the arguments for alginite to be included among such materials like zeolites and bentonites which have already achieved a possition for useful agricultural utilization.

Alginite is a 3-4 million year old specifically rock as it is originated from the accumulated fresh water in the caldera of the volcano of the Pannonia Sea. It is due to a special sedimentary process. Rocks washed into the water of the crater started to flake due to the oxygen and bacteria, so the water became rich in nutrients. Being rich in minerals and organic nutrients led to the proliferation of some lower class organisms, for example green algae (*Clorophyta*). The algae built into their organisations the micro- and macro components that helped their existence. After perishing they got into the bottom of the lake among reductive conditions. Majority of the organic materials did not dissolve, but it mixed with the non-organic material and became Alginite. Alginite is organic and it basically consists of algae and non-organic materials such as basalt rubble, calcipelite, dolopelite and diatomite.

Our research focuses on the study of Pincina alginite. Alginity have a layered structure. Its solidity is 0,5-1,5 kg/cm$^2$ and its consistency is 2,1-2,4 gr/cm$^3$. Its water content is 17-35% which decreases to 4-5% under laboratory

*Chapter 3*

# HIGH-PERFORMANCE CERAMIC LUBRICATING MATERIALS

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## ABSTRACT

With the rapid development of modern technology, various machineries have proposed changes in lubricating materials. These are geared toward improving the property of materials and allowing them to surmount severe challenges under extreme conditions (e.g., high/low temperature, special media, atmosphere, etc.) in the fields of aviation, space, nuclear energy, microelectronics, and so on. The ceramic lubricating material is a new solid lubricating material composed mainly of a ceramic matrix, reinforcing phase and solid lubricant. This ceramic lubricating material shows good performance in high temperature and corrosion resistance due to its ceramic-skeleton. Moreover, the ceramic lubricating composite is the only material that can work above 1,000°C, while maintaining low density and excellent corrosion resistance. These materials are considered to be high temperature lubricating technology with the most development potential and practical value. This chapter has

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analyzed the research focus and present problems of ceramic lubricating materials, and then proposed the design principle of these materials. The design, preparation and performance of several typical ceramic lubricating materials were introduced. Based on these studies, we developed a kind of ceramic lubricating composite which has low wear, high reliability and long life, and provide theoretical guidance and technology support for the application of new ceramic materials in the fields of high technology.

## 1. INTRODUCTION

Lubrication problems are the common problems of motive machinery. *There are all* kinds of lubrication problems in the space, ground mechanical equipment and large aircraft carrier. Moreover, high performance lubricating materials are the key to assuring the mechanical system runs in high precision and more stability. With the rapid development of modern technology, various machineries have proposed changes in lubricating materials. These are geared toward improving the property of materials and allowing them to surmount severe challenges under extreme conditions (e.g., high/low temperature, special media, atmosphere, etc.) in the fields of aviation, space, nuclear energy, microelectronics, and so on. In recent years, various types of aerospace engines and space vehicles have developed very urgent requirements for high-temperature lubrication technology. The lubricating materials corresponding to the required conditions in these fields must be capable of *working in* corrosive environments *and* high temperatures above 1,000°C for a long time. However, the conventional solid lubricating material cannot satisfy these application requirements [1]. Lubricating materials are currently facing a series challenge.

Ceramic materials are considered to be potential candidates for high-temperature tribological applications because of their excellent properties, such as high temperature resistance, low specific density, high hardness and anti-oxidation. Unfortunately, the friction coefficient and wear rate of ceramics are very high under dry sliding, which limit their application in the areas of high-temperature lubrication. According to the basic theory of tribology, it is necessary to have a low-shear-strength film on the surface of ceramics to reduce both the coefficients of friction and the wear rates of the materials. To minimizes the friction coefficient and subsequent energy losses, researchers tried to introduce a self-lubricating mechanism in the ceramic-composites.

The ceramic self-lubricating composite is a new solid lubricating material composed mainly of a ceramic matrix, reinforcing phase, and solid lubricant. This self-lubricating material shows good performance in high temperature and corrosion resistance due to its ceramic-skeleton. The solid lubricant can be used to improve the tribology performance of materials, demonstrating excellent self-lubricating properties in a wide range of temperatures [2-4]. Moreover, the ceramic lubricating composite is the only material that can work above 1,000°C, while maintaining low density and excellent corrosion resistance. However, subsequent studies have shown that these composites are homogenous in terms of mechanical and tribological properties. Thus, the strength of ceramics and the lubrication of solid lubricants cannot be fully utilized. In addition, because the continuity of ceramic phases is destroyed by the layered structural solid lubricant phase, the mechanical property of this type of material is reduced. Therefore, the design and fabrication of the composites must be geared toward improving both mechanical and tribological properties, which is also the focus of the ceramic lubricating materials [5,6].

Based on the above background, some new design methods to achieve the integration of structure and lubricating function in ceramic were proposed. On this basis, we developed a kind of ceramic lubricating composite which has low wear, high reliability and long life, and provide theoretical guidance and technology support for the application of new ceramic materials in the fields of high technology.

## 2. Preparation and Tribological Properties of Zirconia/Alumina Nanocomposites with Controllable Grain Size

Ceramic-based nanocomposites are highly attractive materials due to their exceptional properties. Nanocomposites have a new material design concept and significantly improved strength has been achieved with moderate enhancement in fracture toughness. The microstructure of nanocomposites is constructed by dispersing second-phase nano-size particles within the matrix grains and on the grain boundaries. Thermal expansion mismatch between the matrix and second-phase particles produces a marked improvement in mechanical properties such as fracture strength, fracture toughness, creep resistance, thermal shock resistance [2]. In addition, ceramic nanocomposites have more excellent wear resistance than traditional micro-ceramics [7].

gradient exponent of materials, which realize the optimization of the material properties.

## ACKNOWLEDGMENTS

The authors acknowledge financial support from the National Natural Science Foundation of China (51175493), the Program of the Light of the Chinese Academy of Sciences in China's Western Region (2010), and the China National Science and Technology Program of 973 (2011CB706603).

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