

## Chapter 6

# Inorganic–Organic Composite Materials from Liquid Natural Rubber and Epoxidised Natural Rubber Derivatives: Prospects and Applications

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### ABSTRACT

*Organic-Inorganic composite materials (OICs) are used to describe the group of materials synthesized from polymers and inorganic metal alkoxides. The interests in these materials arised from the need to 'combine' the physical properties of inorganic glass materials and polymers such that the resultant OICs have the strength of the inorganic glass and flexibiliy of polymeric materials. Sol-gel technique have been the technique of choice due to much of its advantages, in particular the low temperature reaction. This is very important when natural rubber and its derivatives are used as the polymer component of the OICs. Work in our laboratory has demonstrated that OICs form liquid natural rubber (LNR) and 50% epoxidised natural rubber (ENR-50) can be prepared from various metal alkoxides, such silicon, zirconium and titanium. The OICs can be prepared as flexible transparent films, nanofibers and nano-beads. This Chapter will describe the preparation techniques and the properties of these OICs from various compositions of one and more metal alkoxides in both LNR and ENR-50. The applications of these materials in PANI will be briefly described.*

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## INTRODUCTION

Inorganic-Organic- composite materials (IOCs) is used to describe the group of materials synthesized from polymers and inorganic metal alkoxides. The interests in these materials arised from the need to 'combine' the physical properties of inorganic glass materials and polymers such that the resultant IOCs have the strength of the inorganic glass and flexibility of polymeric materials. Sol-gel have been the technique of choice, due to much of its advantages, in particular the low temperature reaction. This is very important when natural rubber and its derivatives are used as the polymer component of the IOCs. It has been demonstrated that IOCs form liquid natural rubber (LNR) and 50% epoxidised natural rubber (ENR-50) can be prepared from various metal alkoxides, such silicon, zirconium and titanium. The IOCs can be prepared as flexible transparent films, nanofibers and nanobeads. This Chapter describes the preparation techniques and the properties of these IOCs from various compositions of one and more metal alkoxides in both LNR and ENR-50. The applications of these materials in polyaniline(PANI) also are briefly described.

### **Inorganic-Organic Composite Materials and Sol-Gel Techniques**

The interest to combine the properties of inorganic and organic components in order to create new composite materials has been a long time challenge to chemist, particularly material and inorganic chemist. IOC materials are prepared or synthesized to seek new materials with improved properties. Organic polymers possess some limitations such as low thermal stability and poor mechanical, electrical and optical properties due to their intrinsic nature. While inorganic materials are usually known for their excellent thermal, electrical, optical and magnetic properties, addition within polymer components can further improve their properties and enhance their applications. IOCs can generally be prepared or synthesized by combining organic polymers and inorganic components in a chemical reaction. For example, inorganic metal alkoxides, which are usually used as the inorganic component, form the inorganic part of the network in the composites. These composite materials have become an important part of material science research to prepare new materials with excellent mechanical, thermal, electronic and optical properties It is noted that commercial IOCs have been part of the manufacturing industry since 1950s (Sanchez, Julián, Belleville, & Popall, 2005).

There are several routes to prepare IOCs material, but the most prominent is by the sol-gel process which offers unique advantages as followed: homogeneous multi-component system can be easily obtained, temperature required for material processing is considerably low and the rheological properties of the sol allows the formation of thin film, fiber and composite by different techniques such as dip coating, spinning and solvent casting.

The sol-gel process can be define as the formation of metal oxide networks through polycondensation reactions of a precursor in a polymer solution liquid phase (Livage, Henry, & Sanchez, 1988; Livage, 1997). Sol is a suspension of particles of one phase in another major phase (polymer solution). When particles in a sol form continuous network, the sol loses its mobility and becomes a soft solid therefore the sol has formed gel. The sol-gel process begins with a solution of metal alkoxide precursors  $[M(OR)_4]$  and water, where M is a transition metal network-forming element, and R is an alkyl group. Hydrolysis and condensation of the alkoxide are the two fundamental steps to produce a network in presence of polymer matrix. For the most transition metal oxide precursors the hydrolysis and condensation reactions are too fast which resulting in loss of morphological and structural control in the final oxide material.

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