CHAPTER I
INTRODUCTION

Tooth shaded dental restorative material or dental composites are becoming more and more popular. For the restoration of anterior lesions, as well as for the supply of smaller and medium-sized defects in the posterior region, direct composites are used. Per definition, a composite is a mixture of several components; in the case of dental filling composites, a mixture of an organic matrix and inorganic fillers. Usually, the organic matrix is based on methacrylate chemistry, especially cross-linking dimethacrylate like 2,2-bis[4-(2-hydroxy-3-methacryloyloxypropyl) phenyl)]propane (Bis-GMA), ethoxylated Bis-GMA (EBPDMA), 1,6 bis-[2-methacryloxyethoxycarbonylamino]-2,4,4-trimethylhexane (UDMA), dodecamediol dimethacrylate (D_3MA) or triethyleneglycol dimethacrylate (TEGDMA) are used. The currently used commercial restorative composites contain a mixture of various cross-linking dimethacrylates, glass and /or silicon dioxide fillers, and a photoinitiator system. By free radical polymerization of the matrix monomers, a three-dimensional network is formed. The selection of the monomers strongly influences the reactivity, viscosity and polymerization shrinkage of the composite paste, as well as the mechanical properties, water uptake and swelling by water uptake of the cured composites [Moszner and Salz, 2001]

Dental composite were introduced to the market in the 1970s. The first products were cured by UV light, later version by visible light. An advantage is greater depth of polymerization in shorter periods of time [Tirtha et al, 1982]. Since their advent, resin composites have undergone significant development, which continues to improve the longevity of resin composites restorations. However, despite vast improvements which have expanded indications for their use, present-day resin composites still have shortcomings limiting their application. Inadequate resistance to wear (loss of anatomic form) under masticatory attrition, and marginal leakage due to polymerization shrinkage are often cited as being the main problems of resin composites. These advantages warrant a conservative approach to class I and class II cavities and constitute the major hindrance for acceptance of resin composites restorations as a viable alternative to amalgam [Full and Hollender, 1993;

Ferracane, 1992]. Originally, resin composites were developed in the search for an esthetic filling material for anterior use. Although the durability of restorations can never be too long, the obtainable longevity of anterior composites fillings seem to be satisfactory to dental professional. Much research is now directed at formulating a resin composite filling material capable of substituting for amalgam. It would appear from the above review that, especially for use in large posterior cavities, resin composites are still in need of improvement, and that a considerable amount of work is being done in effort to upgrade key properties. The main shortcomings of resin composites, which hamper their total substitution for amalgam, are polymerization shrinkage and inadequate resistance to wear under masticatory forces. Obviously, the properties and hence the performance of resin composites are dependent upon the three basic components of material. Some of the properties are mainly related to the filler and the coupling agent, whereas other properties mainly stem from the resin matrix. The first group of properties include strength, stiffness, abrasion resistance, and coefficient of thermal expansion, while color stability and softening tendency can be found in the second group. A third group of properties may be identified that, to a higher degree, depends on both filler and matrix. Such properties are polymerization shrinkage and water sorption. However, as most properties are derived from all three basic constituents is not very sharp e.g. mechanical properties are, as stated, highly influenced by the filler and the coupling agent, but also the organic matrix plays a significant role for strength, stiffness, and abrasion resistance. Although the performance of resin composite is the result of an interplay between all the components present in the material, a change in the monomer system will, all other things being equal, be reflected in the performance of the resin composite [Peutzfeldt, 1997].

Polymer layered silicate nanocomposites are the new class of inorganic-organic material. The materials design and synthesis rely on the ability of layered silicates to intercalate in the galleries between their layers a wide range of monomers and polymers. The term "nanocomposite" implies that the physical arrangement of the different phases is on a scale of less than 100 nm [Roy et al. 1986]. The advantage of reducing the scale of composite material microstructure to less than 100 nm is the remarkable improvement in properties e.g. stiffness – toughness

combination. In conventionally filled polymers, the constituents are immisible, resulting in a coarsely blended macrocomposite with chemically distinct phases. This results in poor physical attraction between the organic and inorganic components, leading to agglomeration of the latter, and therefore, weaker materials. In addition, the micrometer size particles act as stress concentrators. In nanocomposites, chemically dissimilar components are combined at the nanometer scale and are too small to be stress concentractors. Stronger interactions between the polymer and silicate clay produces improved materials with increased mechanical properties. The structure of the composite depends on the extent to which the organic and inorganic components are made compatible [Ishida *et al*, 2000].

Clays are used as additives because they are composed of layered silicates that can intercalate organic molecule. The clay montmorillonite contains hydrated exchangeable cations in the interlayer space. Neutral, polar "guest" molecules can exchange for these cations, expanding the interlayer space. Various guest precursors can form oxides on subsequent heating, stabilizing the intercalation and essentially "pillaring" the layer structure apart to leave a controlled pore structure [Giannelis, 1996]. The dental resin or dimethacrylate monomer as the guest molecule intercalates in clay galleries for enhancing the properties of dental composites.

Apatitic calcium phosphate is a large family of isostructure compounds derive from the ideal hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$: HAP] in which many substitutions in different fields, for example, as gas sensors, ionic conductors, laser hosts, catalysts, and chromatographic adsorbers. Moreover, they have attracted much interest as substitute biomaterials for damaged bone and teeth over past several decades due to their chemical and crystallographical similarities to the inorganic matrix of hard tissue in vertebrate. As sythetic HAP has good biocompatibility and bioactivity but poor mechanical properties, this material has been widely used in the form of ceramics, films, and plasma spray coating of metal prostheses for implants in medicine and dentistry [Layrolle and Lebugle, 1996].

Our ultimate goal is to achieve fabricating hybrid dental composites competable with commercial composites with multiple features required for dental restorative materials. These three types of filler were chosen: silanized silica (conventional microfiller providing esthetic), calcium hydroxyapatite (macro-micro-

nanofiller providing bioactive and biocompatible to teeth tissue), and modified clays (nanofiller providing low shrinkage, good barrier properties, good pH and thermal stability). Three common acrylate monomers were employed Bis-GMA, UDMA, and TEGDMA.

This primary work was to investigate the effect of filler type, filler content, monomer type and monomer ratio on mechanical properties (strength and hardness) such that one can understand quality of filler – polymer adhesion (failure mechanism) and to obtain optimum formulation for good mechanical properties for further preparation of the hybrid dental composites which will be the next study.