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ORIGINAL ARTICLE

# Liquid crystalline epoxy nanocomposite material for dental application

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**KEYWORDS**
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microhardness

*Background/Purpose:* Novel liquid crystalline epoxy nanocomposites, which exhibit reduced polymerization shrinkage and effectively bond to tooth structures, can be applied in esthetic dentistry, including core and post systems, direct and indirect restorations, and dental brackets. The purposes of this study were to investigate the properties of liquid crystalline epoxy nanocomposites including biocompatibility, microhardness, and frictional forces of bracket-like blocks with different filler contents for further clinical applications.
*Methods:* In this study, we evaluated liquid crystalline epoxy nanocomposite materials that exhibited various filler contents, by assessing their cell activity performance using a 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide assay and their microhardness with or without thermocycling. We also evaluated the frictional force between bracket-like duplicates and commercially available esthetic bracket systems using Instron 5566.
*Results:* The liquid crystalline epoxy nanocomposite materials showed good biocompatibility. The materials having high filler content demonstrated greater microhardness compared with commercially available bracket materials, before and after the thermocycling treatment. Thus, manufacturing processes are important to reduce frictional force experienced by orthodontic brackets.
*Conclusion:* The microhardness of the bracket-like blocks made by our new material is superior to the commercially available brackets, even after thermocycling. Our results indicate that the

Conflicts of interest: The authors have no conflicts of interest relevant to this article.

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evaluated liquid crystalline epoxy nanocomposite materials are of an appropriate quality for application in dental core and post systems and in various restorations. By applying technology to refine manufacturing processes, these new materials could also be used to fabricate esthetic brackets for orthodontic treatment.


## Introduction

Social progress and development have increasing demands on personal beauty. In cosmetic dentistry, materials are selected for their esthetic qualities as well as their function in the oral cavity. Anterior alloy restorations are no longer applied in contemporary dentistry because the darkened alloy core and post system affect the appearance of the full ceramic anterior crown. In addition, the difference in the elastic coefficient between the alloy and the residual tooth structure is considerably large, potentially risking failure of the adhesive, rupture of the post, or rupture of the root. Metal brackets can also prompt allergies in orthodontic patients because of their slight nickel composition.[1,2] These factors can cause patients to refuse orthodontic treatment to resolve oral hygiene problems caused by chewing disorders and crowded teeth.

Cosmetic brackets have been successfully produced using various materials; however, problems remain.[3] Although the esthetic quality of the porcelain bracket is appropriate, its fragility can cause tooth wear and bracket breakage during clinical manipulation.[4,5] If the porcelain bracket is fractured, it must be immediately replaced. Polycarbonate has recently been used in cosmetic brackets because of their light weight and thinness. However, if the metal sheet is not appropriately installed in the slot of the polycarbonate bracket (potentially affecting the esthetics), the slot can lose its original shape because of grinding of the orthodontic wire; thus, the bracket can no longer be used.[6,7]

Nanocomposite materials are the primary dental filling materials because they can be conveniently applied and yield a high esthetic quality. Nanocomposite materials are used to fabricate core and post systems and dental brackets, and applied in various restorations (inlays, onlays, veneers, and crowns). However, the volume of conventional nanocomposites is reduced during the curing process. This phenomenon introduces a gap between the restoration and the restored tooth, potentially causing the recurrence of secondary caries.[8,9] Nanocomposites used in major restorations can be susceptible to wear caused by heavy chewing, and their hardness decreases over time when water and bacteria are absorbed. Further development is required to eliminate the disadvantages of nanocomposite materials and expand their dental applications.

Liquid crystalline epoxy nanocomposite materials can be applied in direct or indirect clinical restorations and used to fabricate dental core and post systems and dental brackets.[10,11] Epoxy nanocomposite can be polymerized using various curing agents to form a polymer with low shrinkage. In this study, we fabricated material blocks and bracket-like models using new epoxy nanocomposites to evaluate the potential of these materials in dental applications.

## Methods

### Material block fabrication

The material blocks were fabricated in cylinders (height, 2 mm; diameter, 5 mm). Primisa (Kerr Co., Orange, CA, USA) and EZ350 (3M ESPE, St. Paul, MN, USA) were fabricated according to the manufacturer's instructions and used as the control groups. In the experimental groups, the liquid crystalline epoxy nanocomposite resin was used and its compositions were provided by the Institute of Polymer Science and Engineering, National Taiwan University[10]; the major component is epoxy resin ERL 4221 that contains 0%, 5%, 10%, 20%, and 30% liquid crystalline biphenol epoxy resin, respectively. The material blocks were fabricated using a heat-curing method. The nonsticky silicon mold was preheated in an oven at 70 °C for 60 minutes. The material ingredients were then mixed and preheated at 70 °C for 10 minutes. The material was poured into the silicon mold at 70 °C and left for 30 minutes. The temperature was then increased at a rate of 10 °C/minute until 160 °C, and the material blocks were heat cured for 3 hours, before being gradually cooled to room temperature. More than 40 blocks were fabricated for each material.

Spirit MB plastic brackets (Ormco Co., Orange) and Rave resin brackets (Ortho Technology, Tampa, FL, USA) were selected for comparisons of microhardness with the bracket-like material blocks before and after thermocycling. In this study, we used nonsticky silicon mold to copy the Rave brackets, and duplicate more than 40 bracket-like blocks for further examination according to the aforementioned heat-curing procedures.

### 3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide assay

The cellular viabilities of cells on the studied biomaterials were determined using 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT; Sigma-Aldrich, St. Louis, MO, USA) assay. The MTT assay is based on the reduction of yellow tetrazolium bromide to a purple formazan product by mitochondrial dehydrogenases activity in active cells.[12] Crystals of MTT (Sigma-Aldrich) were mixed with 30–40 mL of phosphate-buffered saline to form a 5 mg/mL solution. The solution was filtered using a 0.22-mm filter (Merck Millipore, Billerica, MA, USA), covered with aluminum foil, and stored at 4 °C. A dimethyl sulfoxide (DMSO) solution was also filtered using a 0.22-mm filter (Merck Millipore, Billerica, MA, USA).

Three blocks of each material were chosen for the MTT test. The surface area of each material block (comprising 0%, 10%, 20%, or 30% liquid crystal biphenol epoxy resin, respectively) was calculated to determine the required volume of Dulbecco's modified Eagle's medium (DMEM; 1 mL