

## Development of Motion Detection Sensors from 3D Printed Natural Rubber and Nitrile Rubber Composites Filled with Barium Titanate and Conductive Carbon Black

Lyhav Boeurn<sup>1</sup>, Sasitorn Srisawadi<sup>2</sup>, YeamponNakaramontri<sup>1</sup>

e-mail: yeampon.nak@kmutt.ac.th

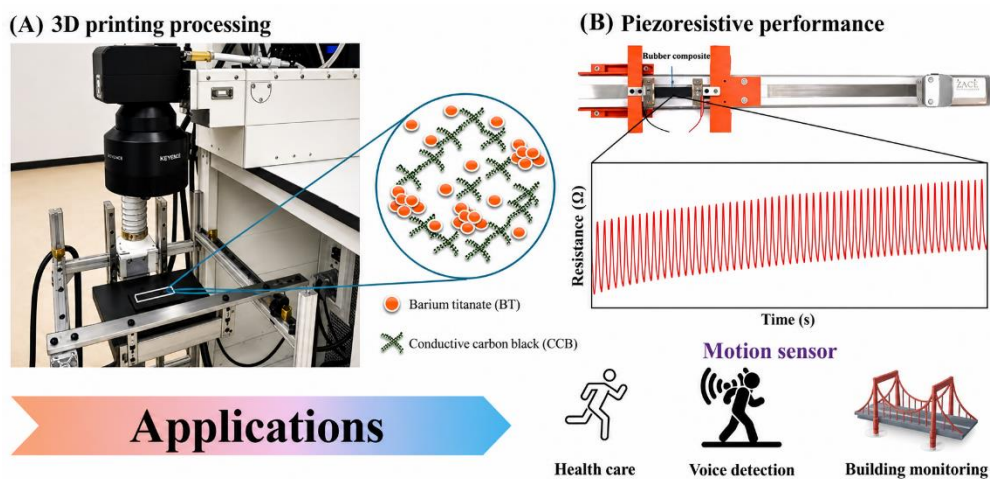
<sup>1</sup>*Sustainable Polymer & Innovative Composite Materials Research Group, Department of Chemistry, Faculty of Science, King Mongkut's University of Technology Thonburi, Bangkok, Thailand.*

<sup>2</sup>*National Metal and Materials Technology Center, 114 Thailand Science Park, Phahonyothin Road, Khlong Nueng, Khlong Luang, Pathum Thani 12120, Thailand.*

### Abstract

Polymer-based flexible motion sensors have attracted considerable attention due to their wide range of potential applications. Natural rubber (NR) is a promising matrix for flexible conductive polymer composites because of its excellent elasticity and fatigue resistance [1]. Similarly, nitrile rubber (NBR) has gained research interest owing to its polarity, which promotes filler–matrix interactions and enhances electrical conductivity [2]. In this study, NR and NBR were used as polymer matrices filled with conductive carbon black (CCB) and barium titanate (BT) as hybrid functional fillers. The composites were fabricated using both casting and stereolithography (SLA) 3D printing techniques (Figure 1(A)). Electrical conductivity was evaluated using a Keysight E4990A impedance analyzer (Keysight Technologies, Malaysia), while the internal morphology was examined using an optical microscope (BEC-SF-4000-A, Becthai Bangkok Equipment & Chemical Co., Ltd., Thailand). The piezoresistive behavior of the composites was investigated under cyclic testing deformation at strain ranges of 0–50% and 0–100% to assess their motion-sensing performance (Figure 1(B)). The results showed that composites fabricated by 3D printing exhibited lower electrical conductivity than those prepared by casting. This was attributed to the disruption of the CCB conductive network during the SLA process, likely caused by UV laser exposure, which increased the electrical resistance [3]. This observation was supported by optical microscopy results. In terms of piezoresistive performance, NR composites prepared by casting showed lower sensitivity than those produced by 3D printing, whereas NBR composites exhibited the opposite trend. This behavior may be related to the higher polarity of NBR, which enhances its interaction with BT. Overall, both NR- and NBR-based CCB–BT hybrid composites demonstrated successful piezoresistive responses under tensile loading. These materials show strong potential for flexible sensor applications, including voice detection, structural health monitoring, and motion sensing.

**Keywords:** Natural rubber, Acrylonitrile butadiene rubber, Hybrid filler, 3D printing technique



**Figure 1** The three-dimensional (3D) printing processing (A), the experimental setup to elucidate the piezoresistive performance (B), and the application of rubber composites.

## Reference

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