Electroelastic Response of a Piezoelectric Fiber of Poly-L-lactic Acid under Axisymmetric Mechanical Load

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ABSTRACT

Poly-L-lactic acid (PLLA) is expected to be employed in the human–machine interface devices and surgical instruments [1, 2]. For safe operation of such applications, the electroelastic field inside the material must be elucidated. In PLLA, the coupling between an electric field and the shearing motion around it plays important roles, which is quite unlike other popular piezoelectric polymers.

Among piezoelectric polymers, polyvinylidene fluoride (PVDF) has been widely used because of its superior coupling effect. It has the symmetry which belongs to point group 6mm. For such materials, the electroelastic problems under various conditions were solved [3–5]. As for PLLA fiber, however, the solutions to such problems are not found in the literature due to the peculiar anisotropy of PLLA fiber.

In this paper, therefore, we analyze the electroelastic field in a PLLA fiber. As an analytical model, we treat a solid, infinitely long cylinder subjected to a locally distributed pressure combined with torque, which constitutes one of the most elementary models of a microtweezer or catheter working on its target objects.

First, the displacement and electric field are expressed in terms of the potential functions. The governing equations for these functions are obtained by the equilibrium equations of stresses and the Gauss law. By solving the governing equations, the electroelastic field quantities are obtained. Moreover, by performing numerical calculation, the field quantities, including stress, electric potential, and electric field, are investigated qualitatively and quantitatively, which serves for engineering applications of PLLA fibers.

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