

Dynamic Viscoelasticity of Hydrated Phospholipid Polymer Brush Measured by Fiber Wobbling Method

CATEGORY OR KEYWORDS

Phospholipid, MPC, Polymer brush, Viscoelasticity, Rheology

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INTRODUCTION

2-methacryloyloxyethyl phosphorylcholine (MPC) has a molecular structure in which a phospholipid (phosphorylcholine group) and a methacryloyl group are linked. A phosphorylcholine group is a molecular structure present on a cell membrane surface. When methacryloyl groups polymerize, they are called MPC polymers. By coating with MPC polymer, the chemical composition is similar to the cell membrane surface, so it is possible to realize a biocompatible surface with excellent protein adsorption suppression and antithrombotic properties [1]. In fact, it is applied as a coating agent for artificial blood vessels, artificial hearts, stents, artificial joints and contact lenses. When it was applied to artificial joints, it was reported that they have wear resistance and lubricity as well as biocompatibility [2]. This is explained as a hydration lubrication realized by the MPC polymer retaining water. Kyomoto et al. reported the polymer brush film of MPC showed especially low friction [3]. In this study, to elucidate the detailed mechanism of the lubricity of the hydrated MPC polymer brush film, we measured the shear gap dependence of its dynamic viscoelasticity by using the fiber wobbling method.

MATERIALS AND METHODS

We developed the fiber wobbling method (FWM) that can measure the dynamic viscoelasticity of liquid sample and polymer melts sheared under the precisely controlled nano gaps (Fig. 1) [4]. In this study, we measured the $\tan \delta$ (the ratio of the viscosity and the elasticity) of hydrated MPC polymer films by using FWM. A polymer brush film of MPC was formed by graft polymerization from a substrate [5]. The film thickness was about 40 nm in a dried condition. Before each measurement the samples were immersed in ultrapure water to be hydrated.

RESULTS AND DISCUSSION

Figure 2 shows the results of the gap dependency of $\tan \delta$. The film was viscous ($\tan \delta > 1$) at the gaps wider than 100 nm, and changed to elastic ($\tan \delta < 1$) along with the narrowing of the gap. In the transition region, we found there was a plateau where $\tan \delta$ was almost constant with respect to the gap change. This plateau means that the viscoelasticity (the ratio of viscosity and elasticity) of the film does not change even under the compression between the surfaces of probe and substrate. We considered this was because the polymer density was kept constant in this gap region due to the high flexibility of the polymer brush.

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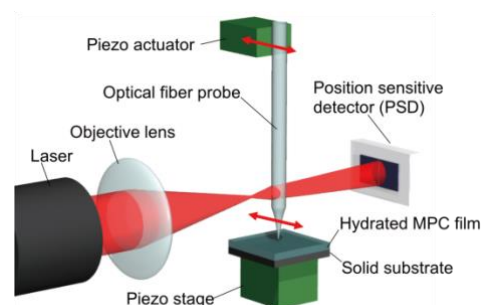


Fig. 1 Schematic diagram of fiber wobbling method (FWM)

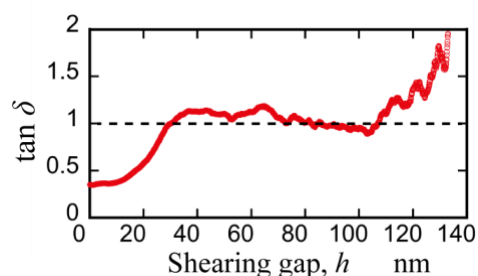


Fig. 2 $\tan \delta$ of grafted MPC polymer brush film measured in hydrated state using FWM.