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# Adhesion of melanoma cells to the microsphere surface is reduced by exposure to nanoparticles

Hiroyuki Shinto *, Yoshinori Ohta, Tomonori Fukasawa

*Department of Chemical Engineering, Kyoto University, Katsura Campus, Nishikyo-ku, Kyoto 615-8510, Japan*

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ABSTRACT

It is of fundamental importance to better understand the interactions of nanoparticles with mammalian cells, such as cellular uptake of nanoparticles and the resultant cellular responses. In the present study, we have measured the interaction force of single nanoparticle-treated cells with a microsphere surface, using atomic force microscopy (AFM) with colloid probes. It was found that the adhesion force of murine melanoma cells to the surface of a 6.90-μm carboxyl-modified polystyrene (PS-COOH) microsphere was significantly reduced by exposing them to the 40-nm PS-COOH nanoparticles in a serum-free culture medium for 15 min, although the nanoparticle treatment of the cells up to 180 min hardly affected their morphology, membrane integrity, and metabolic activity. Possible mechanism of this phenomenon will be discussed.



## 1. Introduction

In the past decade, nanoparticles and their interactions with the soft surfaces of biological systems like cells have been a focus of many research groups [1]. This is largely because many kinds of manufactured nanoparticles have promising application in the field of biomedicine such as biosensors, drug delivery, gene delivery, and disease diagnoses/therapy, where the interactions of nanoparticles with cells play key roles in performing their biomedical functions [2]. On the other side of this, one of the major concerns regarding applications of the nanoparticles is the potential risks such as toxic effects adverse to human health due to their small size, high reactivity, and large surface area [2–5]. The widely studied and used nanoparticles include metals [2,5,6], metal oxides [5–7], silica [8,9], carbon-based nanoparticles [2,5,6], polymeric nanoparticles [1,10], and quantum dots [2,5]. Cellular uptake, location and translocation, and resultant cytotoxicity of these nanoparticles have been extensively investigated and published in lots of literatures (see the references cited in Refs. [1–10]). No literature has reported on how the adhesion of mammalian cells to substrata is affected by nanoparticle treatment, although this cell–substrate adhesion plays a fundamental role in many processes within multicellular organisms. These processes include the formation and the cohesion of tissues, cell differentiation, cell motility, and pathologies such as cancer proliferation and metastasis.

In our previous study [11], we have measured the interaction forces of the murine melanoma cells with the single polystyrene (PS) microspheres of different surface chemistries in serum-free culture media. The results indicate that the unmodified hydrophobic polystyrene (unmodified PS) microspheres interact weakly with the cell surfaces through van der Waals forces and hydrophobic forces, whereas the carboxyl-modified polystyrene (PS-COOH) microspheres interact rather strongly with the cell surfaces via integrins that are transmembrane adhesion molecules acting as cell-adhesion receptors. Likewise, the PS-COOH nanoparticles, rather than the unmodified PS nanoparticles, are expected to have great impact on the adhesion of cells to substrata. The aim of the present study is to demonstrate how the adhesion of mammalian cells to substrata is affected by nanoparticle treatment.

In the present study, we report for the first time the adhesion of "nanoparticle-treated cells" to a substrate using atomic force microscopy with colloid probes, which enabled us to measure the interaction forces between a living cell and a microsphere in a culture medium [12]. We employed the murine melanoma cells as the target cells, the fluorescent PS-COOH nanoparticles as those incubated with the cells in a culture medium, and the PS-COOH microspheres as the substrate for cell adhesion. Cellular uptake of the nanoparticles as well as morphology, membrane integrity, and metabolic activity of the nanoparticle-treated cells were also investigated.

* Corresponding author. Tel.: +81 75 383 2671; fax: +81 75 383 2651.
*E-mail address:* shinto@cheme.kyoto-u.ac.jp (H. Shinto).

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