**Measurement of Effect of Infrared Radiation on Muscle Performance using Nanofabricated Cantilevers**

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**Abstract:**

We investigated the dynamics of isolated *Mytilus* anterior byssus retractor muscle thick filaments manipulated by nanofabricated silicon-nitride levers. Single thick filaments were suspended between the tips of two levers oriented perpendicular to the filaments axis. One was a deflectable cantilever and the other a stationary beam (Figure 1). The same setting was used for investigation of sliding mechanism between single thick and thin filaments. In this case, a thick filament was attached to a stable stiff beam, and a thin filament was hooked to a flexible lever. For the estimation of infrared radiation impact on muscle contraction, single bee flight myofibril was attached between a fine glass needle and a CNF-produced force transducer. Axial stress was applied by translating the base of the deflectable nanolever away from the stationary beam. The tips of the flexible nanolevers and the stationary beam were imaged onto a photodiode array to track their positions. Filament/myofibril shortening and lengthening traces demonstrated steps with a size ~2.7 nm and integer multiples thereof (Figure 2). Steps of this same size paradigm have been seen both during contraction of single sarcomeres [1] and during the active interaction between single isolated actin and myosin filaments [2], raising the question whether all of these phenomena might be related. Active thick filament shortening and thin filament shortening propagation on thick filament are considered as possible sources of length change in sarcomere.

**Summary:**

In investigating the mechanism of muscle contraction, recent experiments on isolated thick filaments from *Mytilus* and *Limulus* have shown that physiological stresses produce filament-length changes of up to 23% and 66% respectively [3]. It has also been found that actin filament can exist...
within two states: short and long, which have a different structural and conformational state of globular actin [4]. All these observations suggest that phenomena of muscle contraction could be not only due to simple sliding of actin and myosin filaments, but also due to conformational changes within the filaments themselves.

In a previous study novel, nanofabricated cantilevers were employed to manipulate single myosin filaments. For the first time it was shown that isolated thick filaments from the anterior byssus retractor muscle of the blue mussel *Mytilus edulis* changed length in steps. Steps were observed consistently and their size was indistinguishable from that found both during contraction and stretching of intact activated sarcomeres, and of isolated activated actin-myosin filament pairs [1,2].

Currently our research group is investigating if thick filament changes can play a major role in muscle contraction. To answer that, we are observing behavior of individual thick filament, attached to nanolevers, during activation.

Another possible partial source of stepwise muscle contraction may be the shortening of the actin filament. In order to answer this question, speckled actin was used. If actin filament shortening takes place during its interaction with myosin, detecting of the length change of the actin filament can be made by measuring distances between the fluorescent markers as functions of time (Figure 3). An assumption is that the length change will propagate from one end of the actin filament to the other.

Following these studies we were working with single actin and single thick filaments. To control both filaments, the micro fabricated cantilevers were used to bring one filament close to the other. Interaction between the filaments was initiated by adding adenosine triphosphate and calcium.

Interfacial water, which makes up 70-80% of cell volume, has shown uniquely different chemical, mechanical and electrical properties than that of bulk water. One such property is how the water is strongly modulated by near-infrared light. To test out the effect of infrared radiation on muscle contraction, myofibrils have been attached to cantilevers of an appropriate stiffness (Figure 4). Matched with a custom-designed, state-of-the-art data acquisition system and control algorithms, forces have been measured by projection of the cantilevers onto a linear photodiode array. Myofibril manipulation and other experiments using the cantilevers resulted in a study that was published in 2008 [5].

References:


