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C₆₀ Clusters Self-Assembly in One-beam Optical Trap

W. Eugene Collins, Weijie Lu, Steven Morgan, and Andrey Zavalin
Physics Department, Fisk University,
Nashville, TN37208, U.S.A.

ABSTRACT

C₆₀ aggregated clusters up to 20 μm length were created on a glass surface within a solution inside of a gradient one-beam optical trap. It was possible to grow rod-shaped structures by motion of an optical trap parallel to the surface of the substrate. After the deposited structures became stable, the solution was dried. By AFM measurements of the stable dried structures, it was shown, that aggregations have typical sizes of 5-15 μm X 1.5-2 μm , and thickness near 1.5 μm . The aggregations consist of thinner (30-100 nm diameter) rods, bundled together.

INTRODUCTION

During the last decade, one-beam optical trapping mostly had applications in the microbiology area [1]. Contributions of the optical trapping to the nanotechnologies could be more significant. The main advantage of the one-beam trap configuration is simplicity and a wide spectrum of possible applications. The quasi-micron size of the optical trap zone and the possibility to precisely control position and motion can satisfy the requirements of micro manufacturing in integrated optics and optical sensors, photonic crystals and bio-chip production.

In the previous experiments for behavior of many particles, trapped in the gradient one-beam optical trap [2,3], it has been shown that trapped particles create quasi-molecular dynamic structures, assembled together by photons and existing only in presence of laser field. Under the certain conditions photon bonding is converted to the chemical bonding [3]. Thus assembled C₆₀ aggregated structures are stable without laser trap and can be used as elements of carbon-based devices.

EXPERIMENTAL DETAILS

The experimental setup, shown in figure 1, is basically similar to the laser tweezers configuration. Trapping laser beam (Nd-YAG, Ti:Sapphire, He-Ne or Ar-ion lasers) was used in the microscope "Nikon Optophot". Optical setup provides conditions for high-gradient laser field in trapping zone, creating 3D potential well and also photon bonding of the particles in solution. C₆₀/toluene solution in concentration of 1×10^{-3} M was placed in the 50- μm -thick optical cell, made from microscope cover glasses. The images of the trapping zone and aggregation growth were monitored by a CCTV camera.

After 0.3-10 min of stable trapping under 0.5-3 mW of laser power, photon bonding is transformed to chemical bonding, providing the growth of C₆₀ aggregation polymers on the substrate. By the slow motion of the optical trap along the substrate surface it was possible to grow rod-shape structures. Next, the solution was dried and AFM images of the aggregated structures on the dry glass surface were studied.

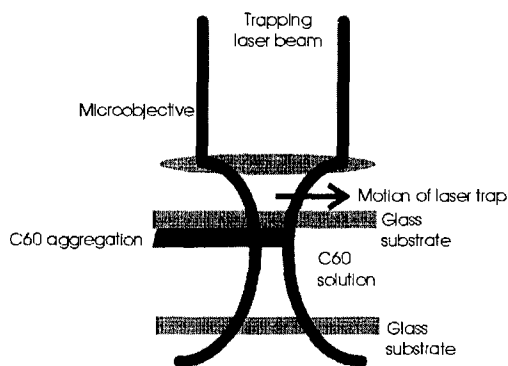


Figure 1. Simplified experimental setup for one-beam gradient optical trap.

DISCUSSION

The AFM image of the dried rod-shaped C_{60} aggregations is shown in figure 2.

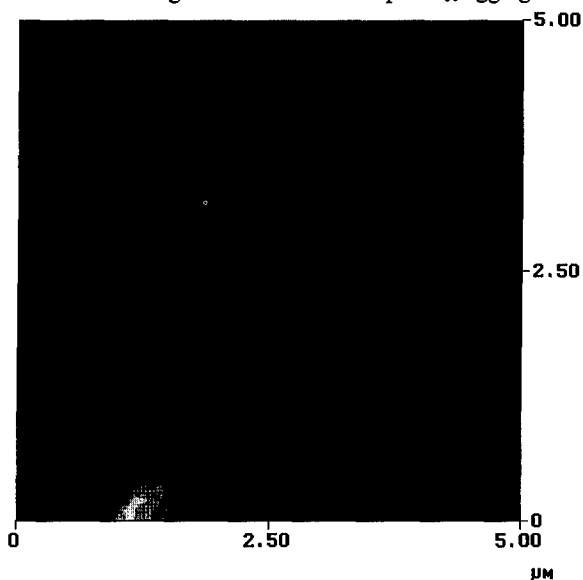


Figure 2. Dried C_{60} aggregations, grown in one-beam gradient optical trap.

Each aggregation contains thinner rods, bundled together. In figure 3, showing section analysis of an AFM image, one can see the rods having 30-100 nm diameters.

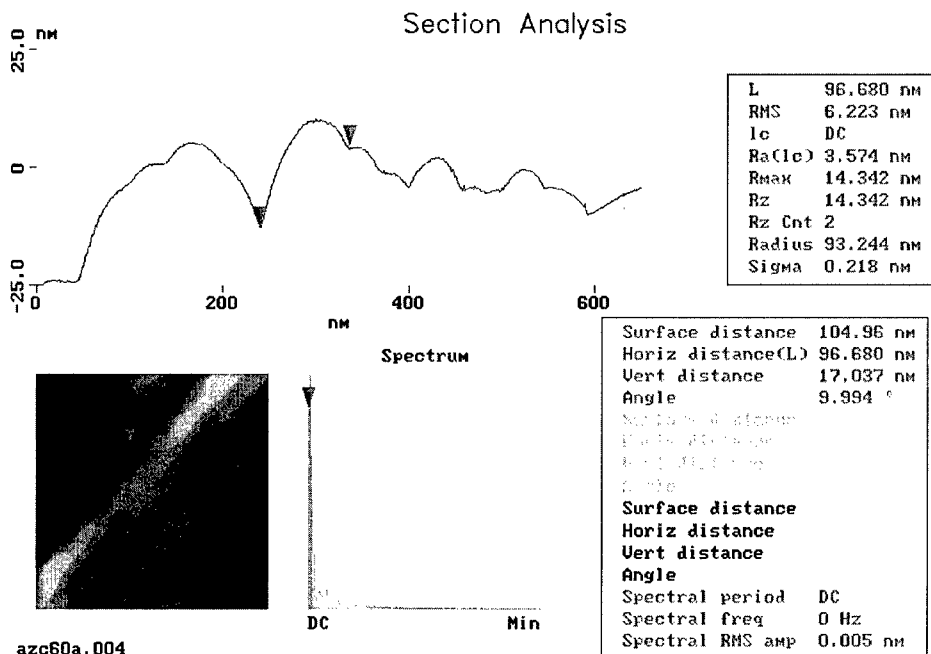


Figure 3. AFM image and section analysis of the C₆₀ rods, bundled together in rod-shaped micron size structures.

In figure 4 the “joint” of the two rod-shaped structures is shown. Under the higher amplification, it is seen that the ends of the thinner rods are without holes. There is no additional information about the core of thinner rods at the present time.

It is important to know if heating of the growing aggregations by trapping laser radiation is a mechanism, which plays significant role in the creation of C₆₀ aggregations. Different laser sources, mentioned above were used for trapping. Similar results were obtained for wavelengths 0.5, 0.63, 0.8, and 1.3 μm , indicating the insignificance of the absorption effect. Unfortunately there was no possibility to measure absorption spectra of aggregations and this is the subject for future research.

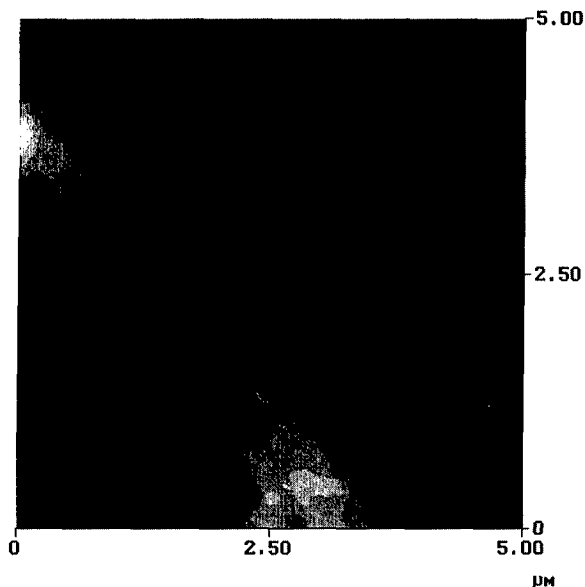


Figure 4. AFM image of the “joint” between the two rod-shaped structures.

CONCLUSIONS

The growth of C_{60} polymer clusters, aggregated inside of the one-beam gradient optical trap, has been demonstrated.

AFM measurements show aggregations having sizes 5-15 μm X 1.5-2 μm , and thickness near 1.5 μm . The aggregations consist of thinner (30-100 nm diameter) rods, bundled together.

Shape of aggregations can be made more elongated by the motion of laser trap parallel to the substrate surface. The quasi-micron size of the optical trap zone and the possibility to precisely control position and motion can satisfy the requirements of micro manufacturing in integrated optics and optical sensors, photonic crystals and bio-chip production.

ACKNOWLEDGMENTS

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