Tools for control of single silver nanowires towards single molecule biochemistry

Joanna Niedziółka-Jönsson#

Institute of Physical Chemistry Polish Academy of Sciences, Kasprzaka 44/52, Warsaw

Because of their 1-dimensional character, silver nanowires (AgNWs) have unique optical properties and can be used as optical antennas and plasmon waveguides. This can increase the quantum yield of reactions in the vicinity of the wire. Plasmon waveguiding uses propagating surface plasmons (SPs) to transfer energy along the nanowire to locations far from the excitation point. It can also collect energy from a molecule coupled with it. There is a trade-off between these two effects, where greater field enhancement limits the propagation of the SP whether the enhancement is achieved by using thinner nanowires or working closer to the plasmon frequency [1-3].

A unique aspect of AgNWs is that their diameter, in the range of 100 nm, is small enough to facilitate plasmonic effects over broad spectral ranges, but their lengths of tens of micrometers make them visible using standard microscopy. We will show the possibility of spatial organisation of single nanowires using optical microscopy which allows a long nanowire be connected to a drop of quantum dot emitters which can then be excited by illuminating the other end of the nanowire. The QDs can also be used to transfer energy from one nanowire to the next, forming the beginning of an optical network of plasmonic wires [4,5].

By immobilizing labeled nucleotides that exhibit fluorescence upon light excitation on high-quality nanowires the plasmonic effect can enhance their fluorescence signal, creating a platform that can be used to monitor enzymatic kinetics. We show that the fluorescence properties of these conjugates depend strongly on the conjugation process. Our initial experiments indicate that the modified AgNWs can serve as effective probes for real-time monitoring of enzyme kinetics in mRNA metabolism, by examining changes of fluorescence intensity.

The research was partially financed by the project OPUS 2023/49/B/ST4/01450 by the National Science Centre (Poland).

[1] Niedziółka-Jönsson J., Maćkowski S. (2019) Materials 12, 1418.
[2] Johns P., Beane G., Yu K.i, Hartland G. V. (2017) J. Phys. Chem. C 121, 5445–5459.
[3] Buczyńska D., Ćwik M., E. Rożniecka, Sulowska K., Piatkowski D., Maćkowski S., Niedziółka-Jönsson J. (2020) J. Phys. Chem. C 124, 15418-15424.
[4] Bialy M., Sulowska K., Wiwatowski W., Cwik M., Buczynska D., Nogala W., Jonsson-Niedziolka M., Piatkowski D, Mackowski S., Niedziolka-Jonsson J. (2025) J. Phys. Chem. C 129, 1260−1269.
[5] Bialy M., Sulowska K., Domagalska M., Szalkowski M., Mackowski S., Niedziolka-Jonsson J. (2025) Phys. Chem. Chem. Phys., 27, 346

corresponding author: jniedziolka@ichf.edu.pl