Temperature-Dependent Raman Spectroscopy of Fullerene Nanocar Wheels

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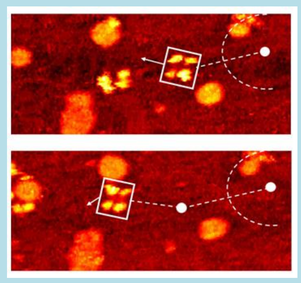
Nanocars as Delivery Vehicles

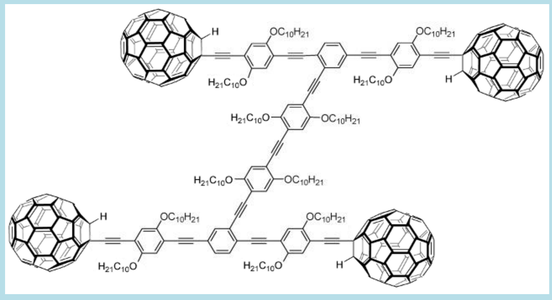
Nanocars are a type of machine consisting of wheels, axles, and a chassis. The four fullerenes, which act as wheels, are attached at the corners of the H-shaped chassis.

Both fullerenes and nanocar molecules have been shown to exhibit rotational movement under various temperatures.

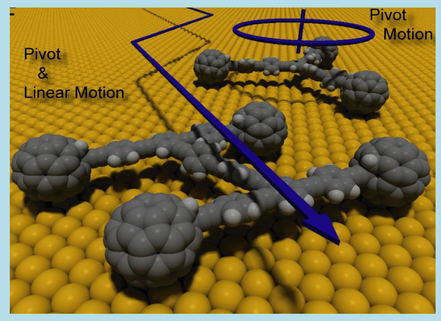
We aim to characterize translational and rotational movement in nanocars, as well as the effects of temperature and substrate. We want to lay the foundations for self-assembling nanostructures, chemical catalysis and biomedical drug delivery.



Scanning Tunneling Microscopy image of nanocar movement under temperature increase



Molecular structure of a fullerene nanocar.



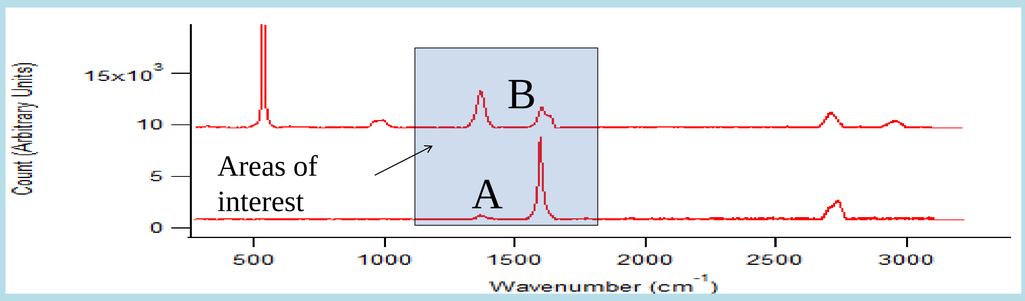
Axis of movement of the nanocar.

Raman of C_{60} and Nanocar Suggests Movement

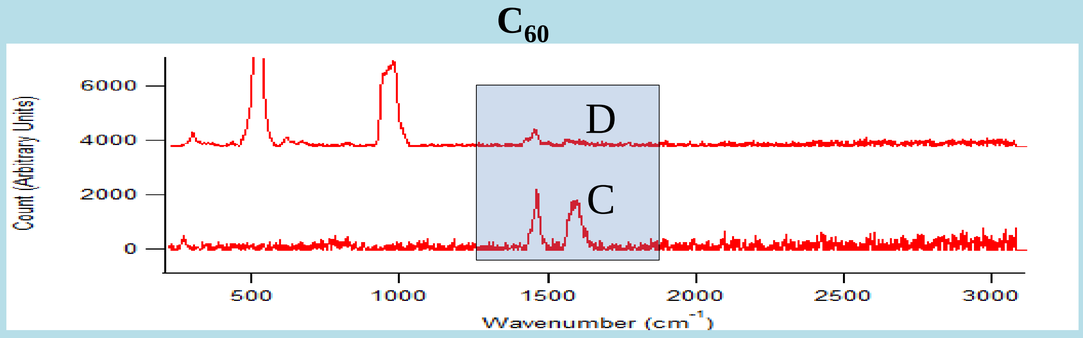
C_{60} is a Van der Waals solid at room temperature, so it bonds by charge transfer which will hold it in place. This is no longer true when the temperature increases.

Exposure Time: 120 seconds
Laser Wavelength: 514.5 nm
Laser Power: 18 mW (100%)

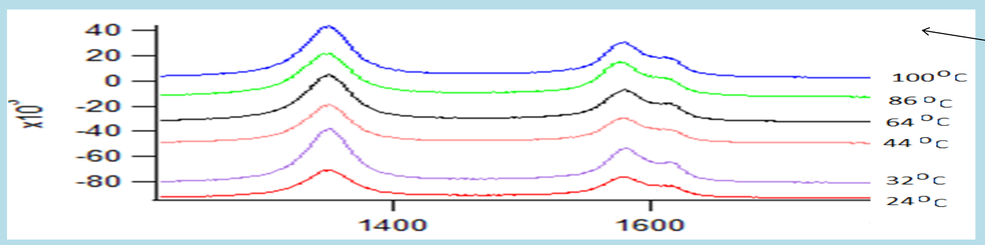
Nanocar



C_{60}

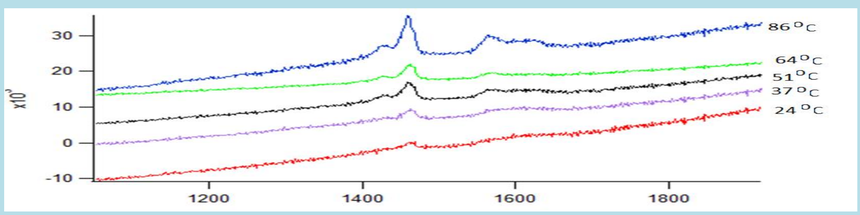


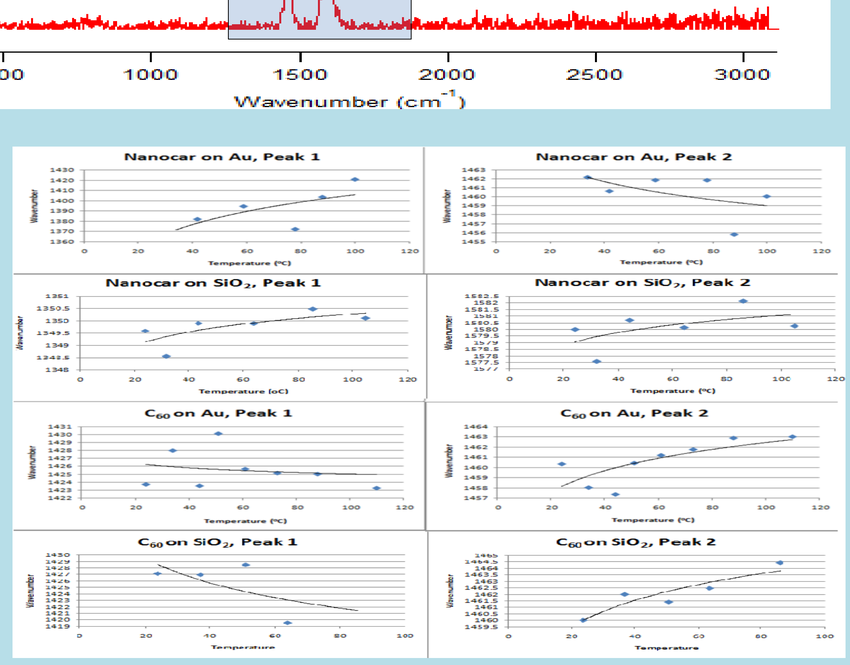
Primary peaks of interest are the Hg(7) and Hg(8) peaks located at 1425 and 1575 cm^{-1}, respectively.



Nanocar on SiO_2 Spectra

Stacked spectra of peaks show the differences that arise due to changes in temperature.





Temperature dependent peak shifts of the nanocar/C_{60} on Au/SiO_2

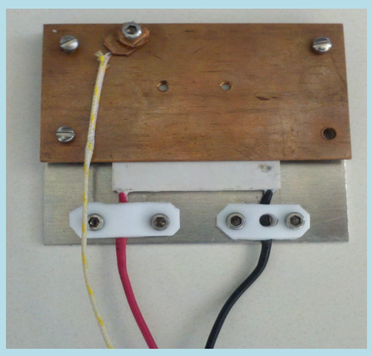
Temperature Dependent Raman for Determining Rotation

Variable Temperature Microscope Stage

The thermoelectric effect turns a voltage drop into a temperature difference.

We can control the input voltage and current by using an external power supply.

A thermocouple attached to the surface of the heater mount is used to measure the device's temperature.



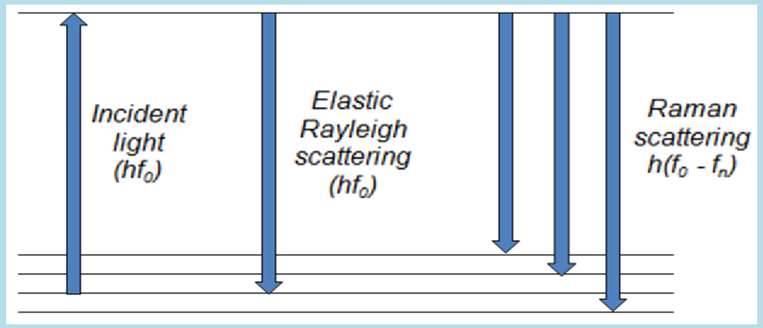
Stage used to control temperature. The red and black wires are connected to the power supply. The yellow wire is the thermocouple. The thermoelectric device is the white piece in the center.

Raman Spectroscopy

We want to characterize the vibrational and rotational modes in the sample.

Scanning Tunneling Microscopy established that the wheels rotate, but Raman will shed insight on rate.

We compare the C_{60} and nanocar Raman spectra to determine how the molecular interactions are different.



Raman Scattering is used to analyze the vibrational and rotational modes of the fullerenes and nanocars.

Conclusion

We have successfully built a variable temperature microscope stage and used Raman spectroscopy to monitor the thermal activation of both C_{60} and fullerene-wheeled nanocars on both gold and silicon dioxide surfaces.

The next step is to compare the energy shift in these vibrational modes with the temperature dependent tunneling microscopy measurements.

References

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