Supporting Information

Development of Pyrene stacked Carbon Nanotube-based Hybrid: Measurement of NO_3^- ions using Fluorescence spectroscopy

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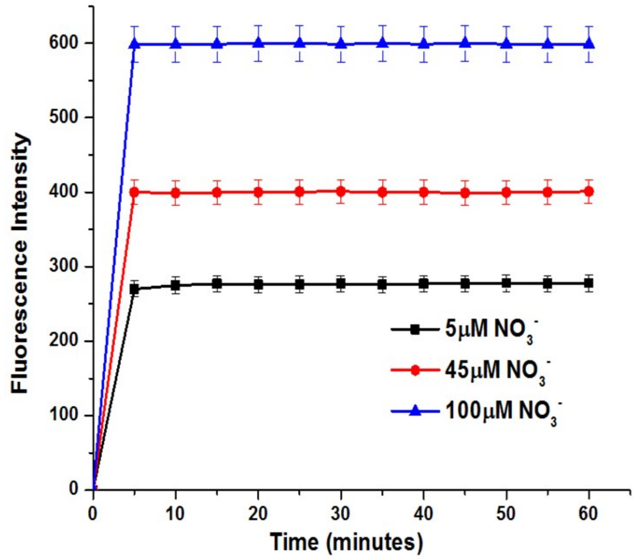


Figure S1: Plot of the response time of Hybrid.NO_3 complex upon addition of different concentrations of NO_3 to the Hybrid solution in a time interval of 1-60 minutes.

Table S1: Comparison data of published manuscripts vs. proposed manuscript on detection of NO_3.

Ligand	Method	Medium	Detection	Detection limit	Reference
Polymer Membrane	Ion elective electrode	-	NO_3^-	$3 X 10^{-5}$ M	42
HNOPH ionophore	Optical	Water	NO_3^-	1.63mg/l	43
Polypyrrole-nanorods	Amperometric	Water	NO_3^-	$5 X 10^{-5}$ M	44
D-Galacto hexodialdose	Amperometric	Water	NO_3^-	-	45
Amide receptor	Electrochemical	Water	NO_3^-	0.2mM	46
Y-NaR Immobilized Electrodes	Electrochemical	Water	NO_3^-	$4 X 10^{-6}$ M	47
Copper nanostructures	Hydrodynamic Amperometry	Water	NO_3^-	$0.59 X 10^{-6}$ M	48
Triacid	Fluorescence	DMSO	NO_3^-	$2.1 x 10^{-6}$ M	49
CNT@Pyrene	Fluorescence and Thermal conductivity	EtOH+ H_2O	NO_3^-	$8.1 X 10^{-9}$ M	Proposed work

Experimentation: Thermal conductivity and Viscosity measurements

Thermal conductivity measurements were performed using a conductive electrode made of platinum. This platinum electrode is held manually in the nano-fluid to determine the heat change and works on the principle of transient hot-wire method. A known current is applied to the electrode, which acts as the heating element as well as a temperature sensor. Amount of heat dissipated raise the temperature of nanofluid in contact with the electrode. To examine the heat change in solution, the thermal conductivity of different samples at one constant temperature was investigated. For every sample at a constant temperature, ten readings were recorded to measure the average value of thermal conductivity. Prior to recording thermal conductivity of desired samples, the electrode was calibrated with standards such as distilled water and glycine provided by the manufacturer. Average value of each sample has been plotted in the graph. Effect of NO_3^- was also recorded, where different concentrations were added to developed CNT@Pyrene hybrid solution. To interpret the liquid flow with respect to time taken, viscosity measurements were performed using Ostwald viscometer. Viscosity was calculated using formula mentioned below.

$$\text{Viscosity} = (\eta/\eta_o)^{1/3}$$

Viscosity was measured for 4 different samples and concentration effect of NO_3^- was also monitored using Ostwald viscometer.

Results: Thermal conductivity and Viscosity calculations

To examine the thermal behavior of developed hybrid, thermal conductivity measurements were carried out. The behavior was investigated for R1, CNT, Hybrid and upon addition of recognized anion (NO_3^-) in Hybrid. All measurements were performed at room temperature to maintain the stability and uniformity. Results in **Figure S2A** revealed that CNTs exhibit a thermal conductivity of 0.52 and R1 exhibits 0.46. It was believed that hybrid provides the combined behavior of both the CNTs and R1; results support the prediction. Also, the addition of NO_3 ions to hybrid solution enhances the thermal conductivity to 0.89. To verify the improvement in thermal conductivity, titration was carried out upon addition of a subsequent amount of NO_3 ions to a hybrid solution. 10µl to 100µl was added to 10 ml of Hybrid solution and results stated that a linear profile is formed upon increment in the concentration of NO_3 ions as shown in Figure S2C. Hence, it can be said that concentration of anion and thermal conductivity are directly proportional to each other. Further, pH effect was noticed for Hybrid and Hybrid.NO_3 complex. It was observed in Figure S2E that thermal conductivity increases up till pH 7-8 afterward it decreases a bit, such profile was observed for both the solutions. Thermal conductivity as a function of temperature was analyzed in a range of 25 ^oC to 55 ^oC temperature as shown in Figure S2F. It was observed that at high temperature, the thermal conductivity of hybrid and NO_3.Complex raises. Thermal conductivity of CNT@Pyrene hybrid rises up to 1 and for

NO_3.Complex it rises up to 3.5 at 55 °C. Measurements of viscosity were also carried out side by side. It was found that CNTs exhibits maximum viscosity because of its unstable suspension in an aqueous medium. However, the Hybrid.NO_3 complex offers minimum viscosity value as shown in Figure S2B.

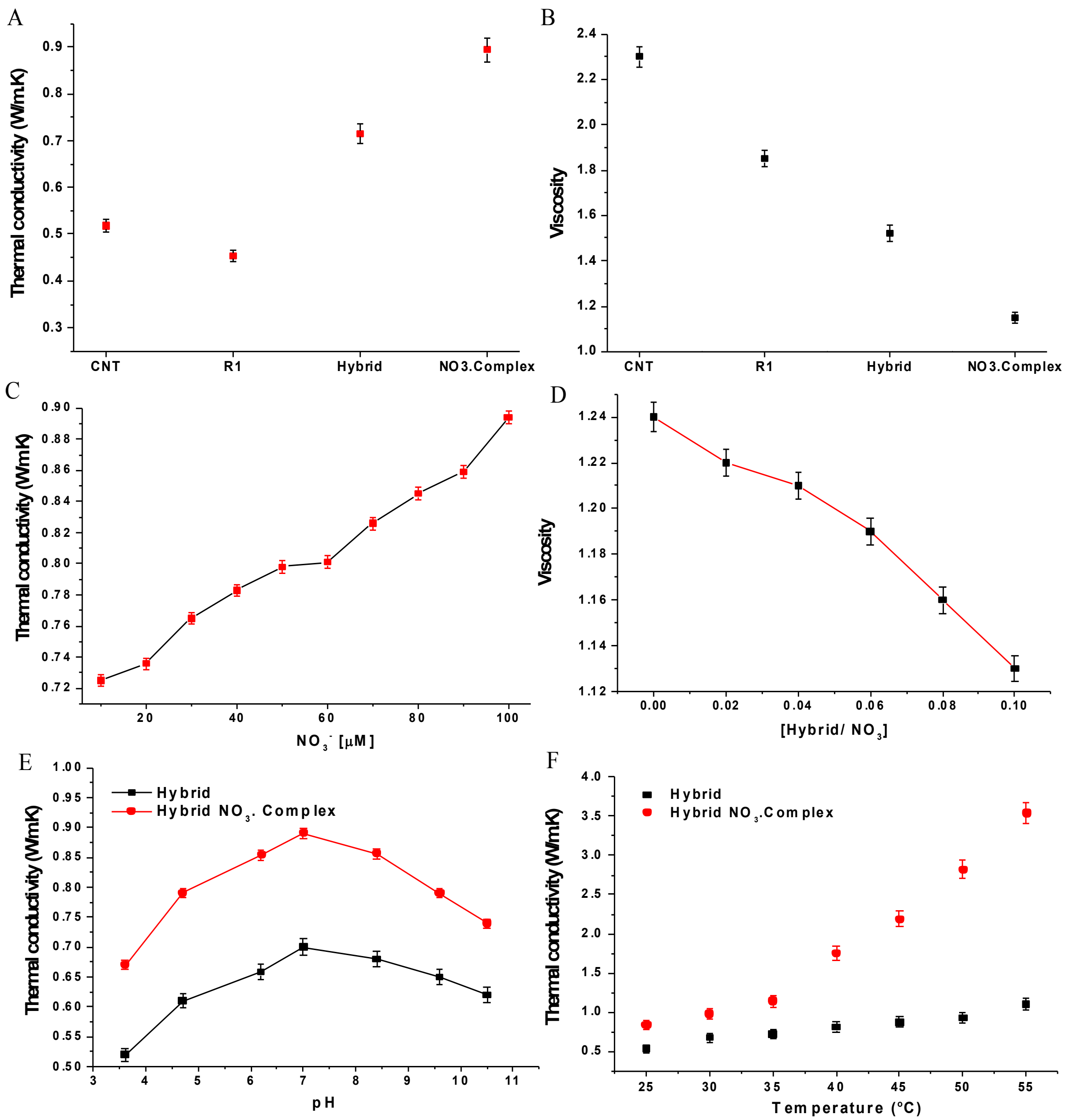
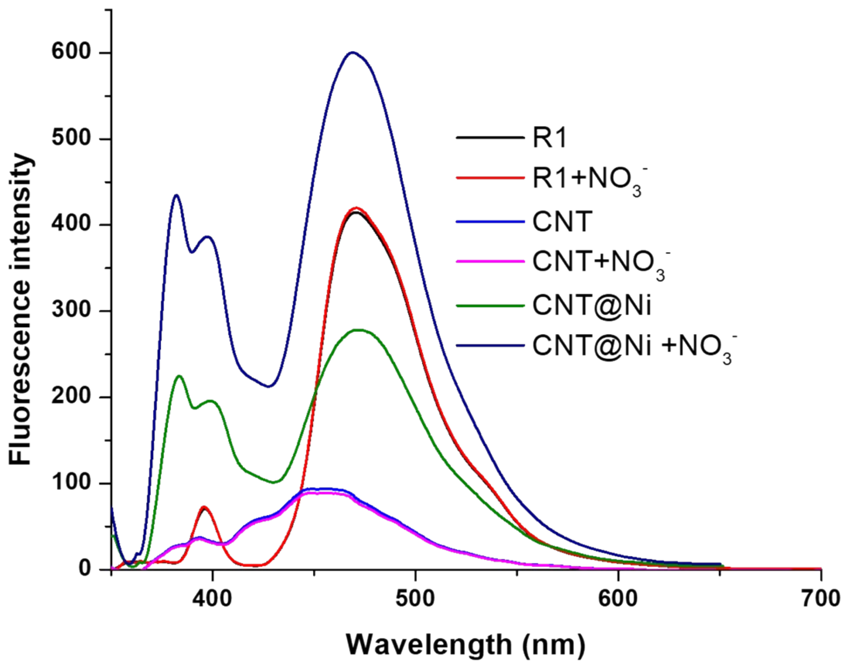


Figure S2: A) Thermal conductivity of 4 different samples, B) Viscosity measurements of CNT, R1, Hybrid and Hybrid.NO_3 complex, C) Varying NO_3^- concentration effect on thermal conductivity of the Hybrid solution, D) Varying NO_3^- ions concentration effect on viscosity of the Hybrid solution, E) Thermal conductivity response at varied pH and F) Thermal conductivity response as a function of temperature.

It is due to the fact that upon addition of NO_3, the final solution becomes clear, there were no suspended particles found. It leads to an easy flow of solution through a u-shaped tube which reduces the time taken and consequent decline in viscosity. Titration was carried out to investigate the viscosity change with respect to anion concentration. A declining trend has been formed in Figure S2D, which depicts a linear decrease in viscosity upon addition of NO_3 to a hybrid solution. Initially, the agglomerated CNT in Hybrid solution restricts the heat transport and led to increase in viscosity. The final stabilization of the solution can be attributed towards the formation of Hybrid.NO_3 complex that has increased the thermal conduct and decreased the viscosity of the final solution.



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