Fluorescence spectroscopic study on the interaction of dopamine and L-dopa with different selenium nanoparticles

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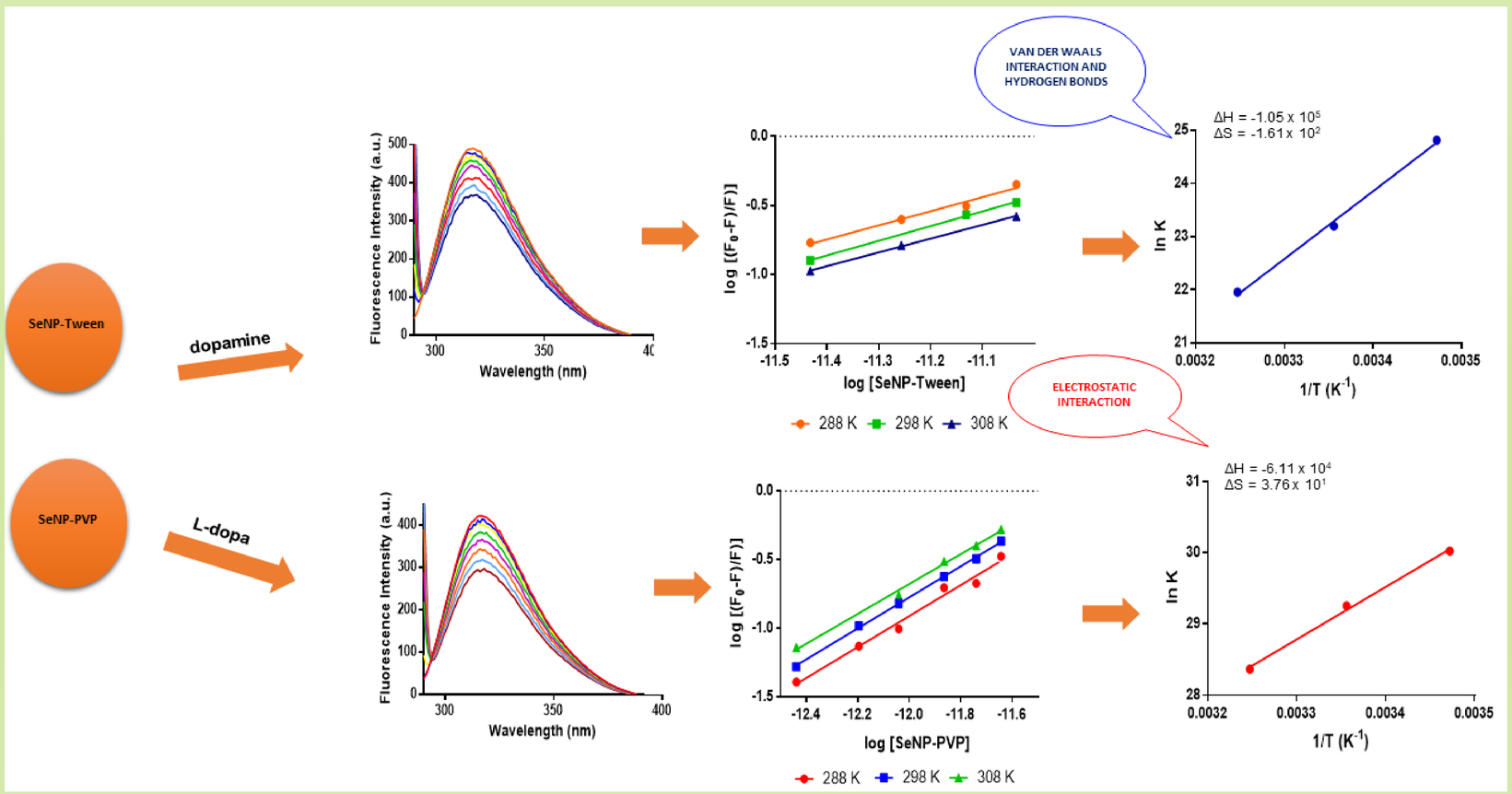
Introduction

The development of new strategies to treat Parkinson's disease suffers from many deficiencies. Common therapy that includes external administration of L-dopa to Parkinson's disease patients is limited due to the lack of targeting ability.[1,2] As an alternative for conventional therapeutic drugs, selenium nanoparticles (SeNPs) constitute an attractive carrier platform for targeted drug delivery into the brain.[3,4]

Methods

In this study, two different SeNPs were designed using polyvinylpyrrolidone (PVP) and polysorbate 20 (Tween) as surface modifiers. The hydrodynamic diameter (d_H) and zeta potential were obtained by dynamic and electrophoretic light scattering, respectively (Table 1). The shape and primary size (d) of SeNPs were examined by transmission electron microscopy (TEM, Figure 1). The binding affinity of dopamine and L-dopa to these SeNPs was estimated from the steady-state fluorescence measurements at three different temperatures. The binding constants and thermodynamic properties involved in the interactions have been calculated using biophysical model analysis (e.g., Stern–Volmer's, Hill's, and thermodynamic equations).

Figure 3. Scheme of the steady-state fluorescence quenching method that provides binding constants and thermodynamic parameters for SeNP-dopamine/L-dopa systems using the Hill's and van't Hoff's equation



Results

Table 1. Hydrodynamic diameters (d_H) with corresponding volume percentages, zeta potential (ζ) and primary diameter obtained from TEM for SeNPs in ultrapure water (UPW) at 25˚C.

Nanoparticles type	d_H/nm (% mean volume)	ζ/mV	d_{TEM}/nm
SeNP-PVP	108.6 ± 1.5 (100)	-24.4 ± 0.4	83.5 ± 7.0
SeNP-Tween	69.5 ± 0.7 (100)	-37.0 ± 0.6	52.4 ± 6.7

Figure 1. TEM micrographs of **a)** SeNP-PVP and **b)** SeNP-Tween

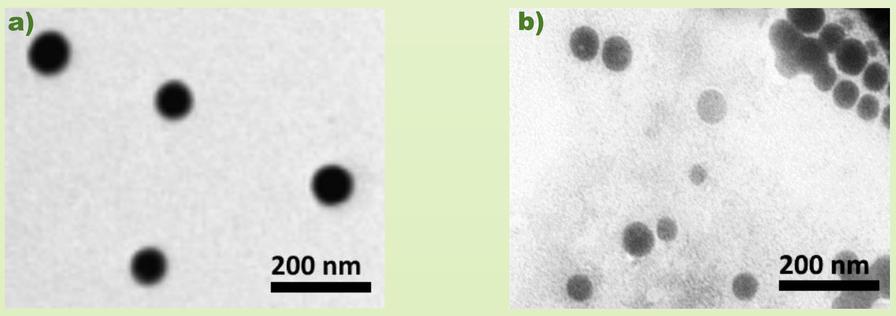
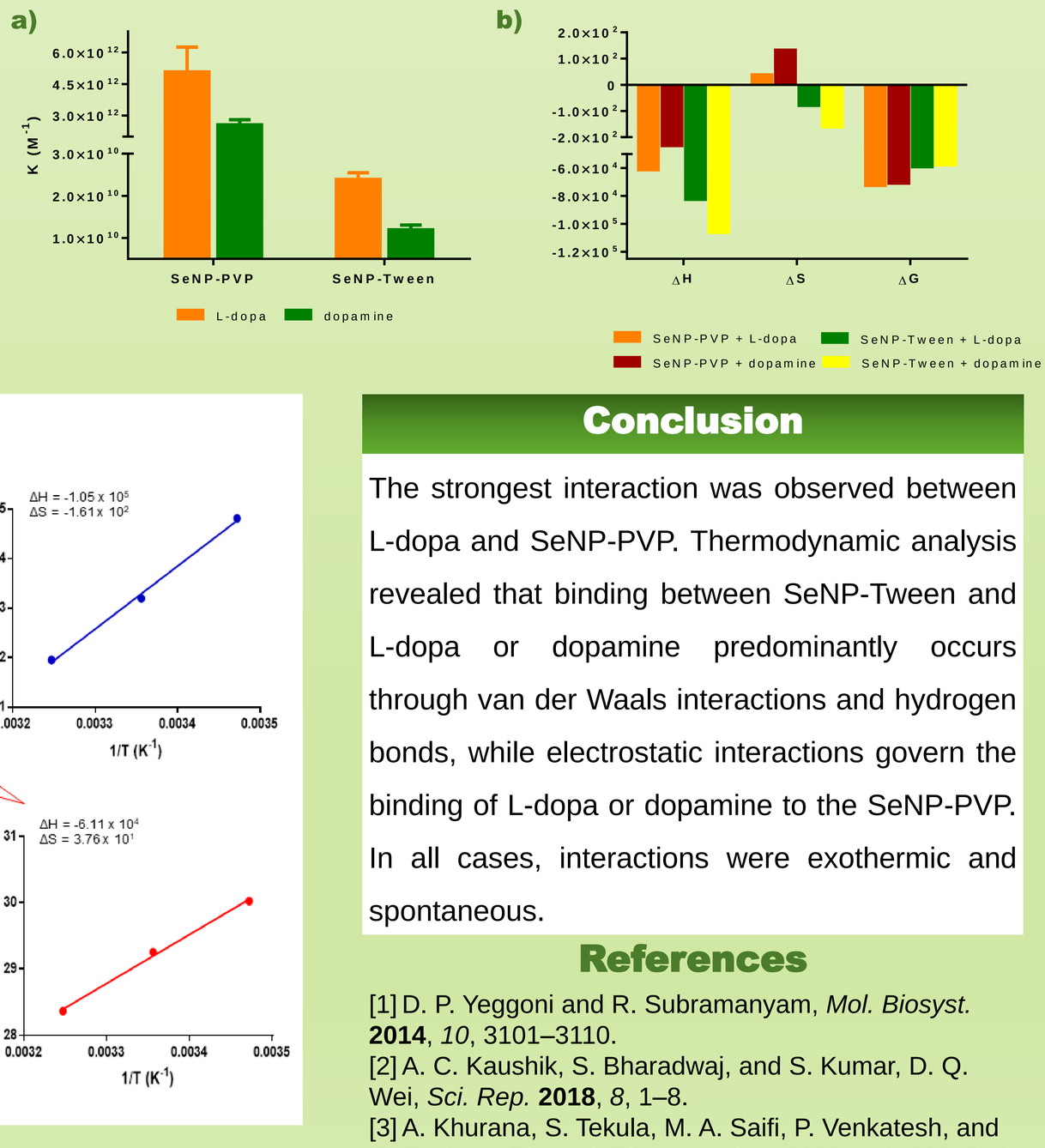


Figure 2. a) Binding constants at 298 K and **b)** thermodynamic parameters for SeNPs-dopamine/L-dopa systems



Conclusion

The strongest interaction was observed between L-dopa and SeNP-PVP. Thermodynamic analysis revealed that binding between SeNP-Tween and L-dopa or dopamine predominantly occurs through van der Waals interactions and hydrogen bonds, while electrostatic interactions govern the binding of L-dopa or dopamine to the SeNP-PVP. In all cases, interactions were exothermic and spontaneous.

References

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