

Thermal and Physical Properties of Pt Nanorods

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Optically resonant metal nanoparticles have become an increasingly popular tool in the various areas. Due to their near-infrared (NIR) optical properties, these metal nanoparticles are compatible with modalities such as *in vitro* optical microscopy. Platinum nanorods display crossways and longitudinal exterior plasmon resonances to facilitate electron oscillations at 90° angle and parallel to the rod duration path, in that order and their longitudinal exterior plasmon wavelengths (LEPWs) are fine from the visible to infrared area. Their absorption side view are at least 5 orders bigger than folks of conservative colourings and the light dispersion by Pt nanorods is numerous orders better than the light discharge from powerfully fluorescent colouring.

Key Words: Platinum nanorod, Nanoparticle, Pt, Absorption, SEM, UV-Visible.

INTRODUCTION

Owing to near-infrared (NIR) optical properties of metal nanoparticles, these metal nanoparticles are compatible with modalities such as *in vitro* optical microscopy. One type of metal nanoparticle widely used is the platinum nanorod which can be tuned to have high absorption cross sections in the visible and near-infrared wavelengths¹. Platinum nanorods (PNRs) exhibit transverse and longitudinal surface plasmon resonances (SPR) that correspond to electron oscillations perpendicular and parallel to the rod length direction, respectively. This tuning is achieved by modifying the aspect ratio of the nanorod, thus red-shifting the peak spectral attenuation concomitant with an increase in the ratio of the longitudinal to transverse dimension. These particles can therefore be used in nanoparticle-assisted photo-thermal therapy (NAPT) to enhance the near-infrared energy absorption of an *in vivo* target and aid in the thermal destruction of tumor tissue. The tenability in the longitudinal exterior plasmon wavelength (LEPW), jointly with powerfully improved dispersion and absorption at the LEPW, creates platinum nanorods practical for the configuration of a lot of functional composite materials, for example, with hydrogel^{2,3}, polymers⁴ silica⁵ and bacteria⁶. Platinum nanorods also have an axial surface plasmon resonance (SSPR)⁷, though one-third that of the LSPR, is still many orders of magnitude greater than quantum dots and nanoshells.

Platinum nanorods in addition presents recompense of high-quality biocompatibility, simplistic training and conju-

gation with a diversity of biomolecular ligands, antibodies and other targeting moieties⁸. They have consequently established broad claim in biochemical sensing, biological imaging and medical diagnostics⁹. Platinum nanorods have established using in materials and optics, including polarizers, filters and used to develop the storeroom density in compact disks. The efficiency of platinum nanorods as scattering-based biomedical imaging compare agents and as thermophoto beneficial agents is powerfully reliant on their spreading and absorption cross sections. In common, elevated scattering cross sections is constructive for cellular and biological imaging rooted in dark field microscopy, whereas great absorption cross sections with small scattering losses permit for photothermal rehabilitation with a negligible laser amount. Additionally, the LEPWs of platinum nanorods are powerfully preferred to be in the spectral range of 650-900 nm (Fig. 1). Light irradiation in this area can go through deeper in tissues and reason less photo damage than UV-visible irradiation¹⁰. As a result, the aptitude to adapt equally spreading and absorption of platinum nanorods with diverse LEPWs is of final significance for practical *in vivo* biomedical imaging and beneficial applications^{1,11}. In this work, as a new research we can take our calculation for the molar extinction relations well as break it up flanked by the spreading and absorption components so we focused on the facilitate better typify the thermophoto efficiencies of platinum nanorods by UV-VIS. For this purpose, the major attitudes are tremendously reliant on the axial diameter of the platinum nanorods.

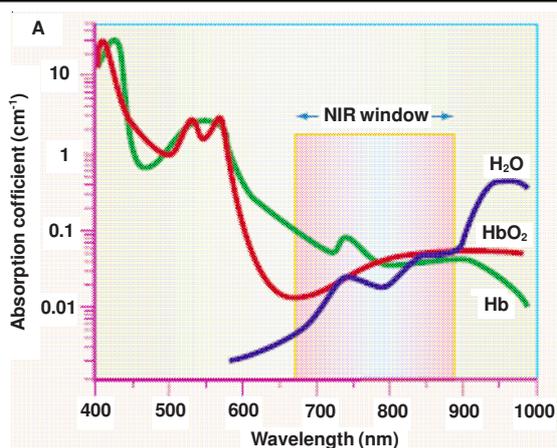


Fig. 1. The near-infrared window is preferably suited for *in vivo* imaging since of minimal light absorption by hemoglobin (< 650 nm) and water (> 900 nm)

EXPERIMENTAL

Hydrogen platinum-chloride ($\text{H}_2\text{PtCl}_6 \cdot 6\text{H}_2\text{O}$ (99.9 %), tri-sodium citrate (99.9 %), L-ascorbic acid (99.0 %), cetyltrimethylammonium bromide (CTAB, 98 %), sodium borohydride (98 %), nitric acid (65 %) were purchased from Beijing Reagents Company in China and used as received. Deionized water was used for all solution preparations and experiments. All the glassware was cleaned by freshly prepared aqua regia, rinsed with tap water and finally washed with deionized water prior to the experiments.

Preparation of growth solution: A 200 mL aqueous solution of 0.00025 M chloroplatinic acid was prepared in a conical flask. 7.29 g of solid cetyltrimethylammonium bromide was added to the solution and the resulting solution was heated until the solution turned a clear orange colour with stirring. The solution was cooled to room temperature and used as a growth solution.

Synthesis of platinum nanorods: Platinum nanorods were synthesized by the three-step seeding growth method as described in the literature. 12-20 four sets of 50 mL conical flasks were labeled A, B, C and D. In flasks A and B, 0.05 mL of 0.1 mL-ascorbic acid was added to 9 mL of growth solution. In flask C, 0.05-0.5 mL of nitric acid and 0.1 mL of 0.1 mL-ascorbic acid were added to 18 mL of the growth solution. The orange colour of the growth solution containing platinum salt and CTAB disappeared when ascorbic acid was added. Next, 1 mL of the prepared Pt seed solution was added to the solution in flask A with stirring for 10 times. After 20 s, 1 mL of sample in flask A was drawing and mixed to flask B with inversion. Then, a 2 mL portion of solution in flask B was transferred to flask C after 40 s. In all the cases, solution in flask C was gently stirred to homogenize the solutions and kept at 25-26 °C in a water bath for 24 h. Produced nanorods can be concentrated and the excess CTAB was removed by centrifugation (TGL-20M high speed centrifuge) twice at 10000 *ref* for 10 min.

Scanning electron microscopy (SEM) images (Fig. 2) were obtained using field emission scanning electron microscopy. The pH of the samples was measured using a Delta 320 pH-meter. The pH of the samples was decreased by adding diluted 0.1M nitric acid.

RESULTS AND DISCUSSION

Thermal stability: The thermal stability of the platinum nanorods was investigated by UV-VIS absorption spectroscopy

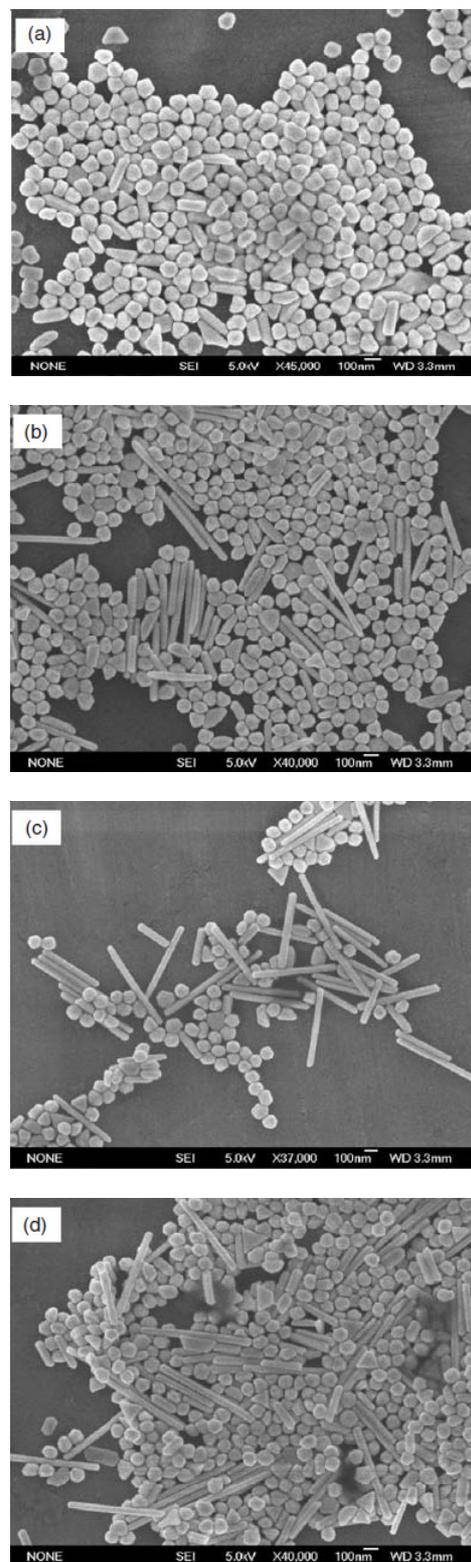


Fig. 2. SEM images of synthesized platinum nanorods by a seeding growth method: (a) without the addition of nitric acid at pH 3.15, (b) with the addition of 0.2 mL nitric acid at pH 2.53, (c) with the addition of 0.3 mL nitric acid at pH 2.48, (d) with the addition of 0.4 mL nitric acid at pH 2.27

technique. It was found that the longitudinal surface plasmon resonance absorption of the platinum nanorods gradually moved to a shorter wavelength at high temperature (Fig. 3), suggesting the decrease of the aspect ratio. The decrease of the aspect ratio could be attributed to the increase of the diameter and the decrease of the length, which was associated with Ostwald ripening in the solution.

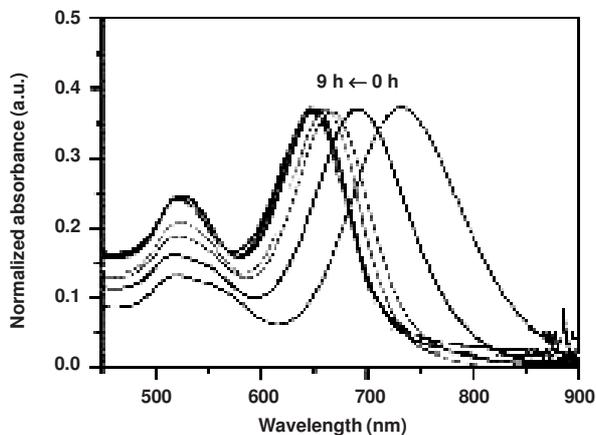


Fig. 3 Relation between wavelength and the absorbance

Photothermal efficiencies: To facilitate better typify the photothermal efficiencies of platinum nanorods, since together absorption and scattering make up the extermination value, we gauge by UV-VIS, we require to decide the proportion that each contributes. These major attitudes are tremendously reliant on the axial diameter of the platinum nanorods. The scattering/extinction relation as a function of axial diameter is given in Fig. 4.

Optical properties of platinum nanorod: PEG-conjugated platinum nanorod were obtained from nanospectra biosciences, Inc. Their visible/infrared extinction spectrum was measured using spectrophotometry. A 1 % dilution of the nanorods was prepared and scanned in spectrophotometer. A normalized spectrum of the nanorods with the emission spectra from the LED's can be seen in Fig. 5.

The stock nanorods had an optical density of 68.3 at 805 nm and optical densities of 24.1 and 13.8 at 660 and 940 nm, respectively.

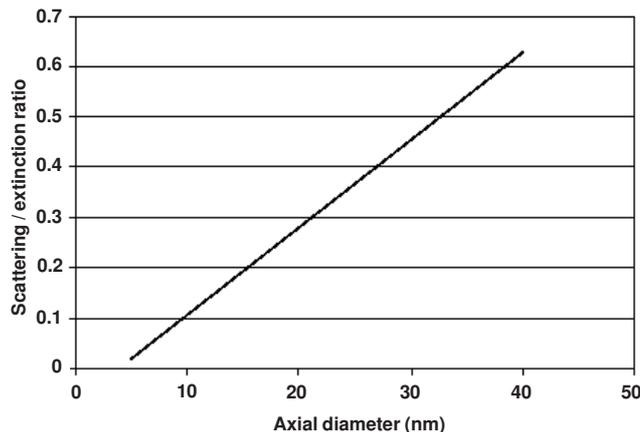


Fig. 4. Spreading/extinction ratio versus platinum nanorod Axial diameter

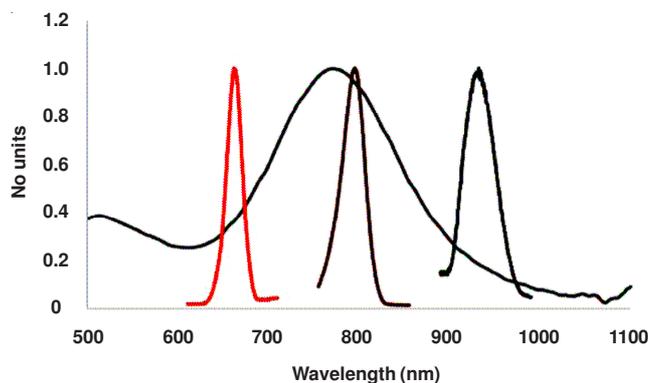


Fig. 5. Normalized extinction spectrum of the platinum nanorods (grey line) with overlaid spectra from the LED's showing the preferential attenuation at 805 nm compared to 660 and 940 nm

From this information, we have computed for the molar extinction relation and break up between the spreading and absorption components. The molar absorption and spreading coefficients for the LSPR are shown in Table-1. The similarity is shown for the SSPR supply by the axial modes in Table-2.

The absorption coefficient for the 10 nm × 45 nm platinum nanorods is seven time smaller amount than the 25 nm × 86 nm platinum nanorods still although the absorption for the 10 nm × 45 nm nanorods is 90 % of the extinction coefficient whereas its only 65 % for the 25 nm × 86 nm. This reduction

TABLE-1
MOLAR ABSORPTION AND SPREADING FOR PNR LSPR

Part # nanorod diam/peak LSPR	Axial diameter (nm)	Longitudinal size (nm)	Peak LSPR wavelength (nm)	OD LSPR (AU)	NPS (mL)	Wt. Conc. (mg/mL)	Molarity (pM)	LSPR Molar Ext. (mL cm ⁻¹)	LSPR molar absorption (M ⁻¹ cm ⁻¹)	LSPR molar scattering (M ⁻¹ cm ⁻¹)	Abs. of incident power through 1 cm at ODI (%)
30-10-850	10	45	850	1.0	5.2E + 11	35.7	874	1.14E + 09	1.03E + 09	1.14E + 08	73.1
30-10-080	10	41	808	1.0	5.9E + 11	36.1	979	1.02E + 09	9.19E + 08	1.02E + 08	73.1
30-10-780	10	38	780	1.0	6.1E + 11	34.9	1020	9.81E + 08	8.83E + 08	9.81E + 07	73.1
30-10-750	10	35	750	1.0	6.4E + 11	34.4	1064	9.40E + 08	8.46E + 08	9.40E + 07	73.1
30-10-700	10	29	700	1.0	6.7E + 11	29.7	1112	8.99E + 08	8.09E + 08	8.99E + 07	73.1
30-25-750	25	86	750	1.0	5.2E + 10	42.9	87	1.14E + 10	7.44E + 09	4.00E + 09	42.1
30-25-700	25	73	700	1.0	1.3E + 11	91.1	218	4.58E + 09	2.97E + 09	1.60E + 09	42.1
30-25-650	25	60	650	1.0	2.6E + 11	149.8	437	2.29E + 09	1.49E + 09	8.01E + 08	42.1
30-25-600	25	47	600	0.9	5.2E + 11	235.1	874	1.03E + 09	6.69E + 08	3.60E + 08	36.4
30-25-550	25	34	550	0.8	5.2E + 11	170.5	874	9.15E + 08	5.95E + 08	3.20E + 08	31.6

TABLE-2
MOLAR ABSORPTION AND SPREADING FOR PNR SSPR

Part # nanorod (axial diam/peak LSPR)	Axial diameter (nm)	Longitudinal size (nm)	Peak SSPR wavelength (nm)	OD SSPR (AU)	NPS (mL)	Wt. Conc. (mg/mL)	Molarity (pM)	SSPR molar ext. ($M^{-1} cm^{-1}$)	SSPR Molar absorption ($M^{-1} cm^{-1}$)	SSPR molar scattering ($M^{-1} cm^{-1}$)	Abs. Of incident power through 1 cm at ODI (%)
30-10-850	10	45	512	0.25	5.2E + 11	35.7	874	2.86E + 08	2.57E + 08	2.86E + 07	16.4
30-10-808	10	41	512	0.25	5.9E + 11	36.1	979	2.55E + 08	2.30E + 08	2.55E + 07	16.4
30-10-780	10	38	512	0.25	6.1E + 11	34.9	1020	2.45E + 08	2.21E + 08	2.45E + 07	16.4
30-10-750	10	35	512	0.25	6.4E + 11	33.4	1064	2.35E + 08	2.11E + 08	2.35E + 07	16.4
30-10-700	10	29	512	0.25	6.7E + 11	29.7	1112	2.25E + 08	2.02E + 08	2.25E + 07	16.4
30-25-750	25	86	530	0.50	5.2E + 10	42.9	87	5.72E + 09	3.72E + 09	2.00E + 09	20.5
30-25-700	25	73	530	0.50	1.3E + 11	91.1	218	2.29E + 09	1.49E + 09	8.01E + 08	20.5
30-25-650	25	60	530	0.50	2.6E + 11	149.8	437	1.14E + 09	7.44E + 08	4.00E + 08	20.5
30-25-600	25	47	530	0.50	5.2E + 11	235.1	874	5.72E + 08	3.72E + 08	2.00E + 08	20.5
30-25-550	25	34	530	0.50	5.2E + 11	170.5	874	5.72E + 08	3.72E + 08	2.00E + 08	20.5

is counterbalance by the detail that the 10 nm × 45 nm has 10 time the concentration at OD 1 than the 25 nm × 86 nm platinum nanorods, combined with the fact that the 10 nm × 45 nm will mingle much, much longer *in vivo* because of their lesser dimension. The SSPR from the axial mode of the platinum nanorods is motionless five orders of scale better than quantum dots in the visible. The LSPR for the 10 nm platinum nanorods absorb over 70 % of incident power at OD 1 in only 1 cm of path length. The SSPR for the platinum nanorods absorb 15-20 % of incident power at OD 1 in only 1 cm of path length.

The selective aptitude to employ exact directional and wavelengths in laser to begin limited to a small area heating has far reaching use in the nanotechnology world.

Conclusion

Platinum nanorod based on semiconducting materials have also been investigated for application as energy harvesting and light emitting devices. Platinum nanorod Researchers used two-photon luminescence (TPL) imaging of single platinum nanorod to track blood flowing through a mouse's ear. As well as enabling 3D imaging, the nanorods provide a TPL signal that's 58 times brighter than the two-photon fluorescence signal from a rhodamine molecule. Platinum nanorod -Scientists have recently determined that platinum nanorod and other nano-

structures can be used to target and destroy tumor cells, but it was generally assumed that cell death was due to the high heat produced by the light-absorbing nanoparticles. Platinum rods can be triggered by a laser beam to blast holes in the membranes of tumor cells, setting in motion a complex biochemical mechanism that leads to a tumor cell's self-destruction.

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