Graphene Oxide@Gold Nanorods Conjugate for Controlled Release of Doxorubicin in tumor

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Date and time : 3.55pm, 22nd Sep 2015

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"There's Plenty of Room at the Bottom"
Richard Feynman
Cancer?

Loss of Normal Growth Control

Normal cell division

Cell Suicide or Apoptosis

Cell damage—no repair

Cancer cell division

First mutation
Second mutation
Third mutation
Fourth or later mutation

Uncontrolled growth

Estimated Cancer Deaths in the US in 2013

Men 306,920
Women 273,430

Lung & Bronchus 28% 26% Lung & Bronchus
Prostate 10% 14% Breast
Colon & Rectum 9% 9% Colon & Rectum
Pancreas 6% 7% Pancreas
Liver 5% 5% Ovary

- American Cancer Society
Factors Believed to Contribute to Global Causes of Cancer

30% Smoking and alcohol use
(172,000 deaths due to smoking and 19,000 deaths due to alcohol use.)

18–20% Chronic infections
(Deaths occur mostly in poor countries due to hepatitis B virus, human papillomavirus, HIV, human T-cell leukemia/lymphoma, and others.)

18–20% Hormones

30–35% Unbalanced diet
(One-third of all cancer deaths due to too many high-glycemic carbohydrates, too many calories leading to obesity, and lack of physical activity.)

2% Occupation
(Deaths occur mostly where pollution is heavy.)

1% Pollution
The flow…

- Synthesis of Graphene Oxide and Gold nanorods
- Characterization
- Photothermal property
- Application
Synthesis of Graphene oxide

Functionnalisation with Arabica acacia
Synthesis Gold Nanorod

Seed Synthesis

GNRs Growth

Growth A (TSPR=528nm, LSPR=748nm)
Growth B (TSPR=531nm, LSPR=595nm)
Growth C (TSPR=537nm, LSPR=620nm)
Growth D (TSPR=534nm, LSPR=626nm)

Absorbance (a.u.) vs. Wavelength (nm)
Formation of Gold Nanorod

(a) Images showing the formation of gold nanorods at different time intervals: 20 min, 40 min, 60 min, 80 min, 100 min, and 120 min.

(b) Graphs showing absorbance (a.u.) vs. wavelength (nm) at different time intervals: 30 min, 60 min, and 120 min. The graphs indicate changes in absorbance at specific wavelengths (e.g., 520 nm, 774 nm, 522 nm, 798 nm, 658 nm, 633 nm).
Schematic representation of the important steps involved in synthesis of the drug delivery vehicle based on graphene oxide and gold nanorods (a) Colors of the solution at various stages of reactions to form final conjugate viz i-GO, ii-GA, iii-fGO, iv-fGO@GNRs and v-fGO@GNR-DOX (b) fGO conjugate (GO-GA) synthesis after reaction of GO with GA (c) Incorporation of fGO in the GNRs (fGO@GNRs) during zipping mechanism (d) Loading of anti-cancer drug DOX on fGO@GNRs complex.
UV-Vis spectra of (a) Graphene Oxide, Gum arabic and their complex and (b) Gold nanorods and its conjugation with fGO.
Electron micrograph showing (a) TEM image of graphene oxide (GO), (b) fGO (c) bare GNRs, (d) FE-SEM image of fGO@GNRs, (e) TEM image of fGO@GNRs displaying magnified view of interactions, (f) enlarged contrasted view of highlighted area of (e) showing clear view of dog-bone shaped GNR on a thin layer of fGO and (g) another TEM image showing dog-bone shaped GNR with other anisotropic nanostructures on a thin sheet of fGO.
TGA of fGO@GNR and final complex and (b) Zeta potential values various components involved in formation of final complex where A: fGO, B: Pure GNRs, C: fGO@GNR & D: fGO@GNR-DOX.
Effect of irradiation time on photothermal temperature of different components in vitro and (b) Infrared image showing increase in temperature of final complex fGO@GNR after 15 min. B. Temp enhancement IR images of PBS, GO, GNR, GO@GNR by using FLIR camera.
Percentage Drug Release with respect to time (a) without NIR and (b) with NIR irradiation.
IC50 values on in vitro cell lines (a) without NIR irradiation and (b) with NIR irradiation where A: GNRs, B: fGO@GNR, C: fGO@GNR-DOX & D: Free DOX.
Trypan blue treatment of A549 cancer cells by GO@GNR and laser
Microtomy

Tissue Fixation

Organ dissection

- Formalin
  - 50 minutes
- 70% Ethanol
  - 50 minutes
- 80% Ethanol
  - 50 minutes
- 90% Ethanol
  - 50 minutes
- 95% Ethanol
  - 50 minutes
- 100% Ethanol
  - 50 minutes
- 100% Ethanol
  - 50 minutes
  - Xylene
  - 50 minutes
- 50 mint
- Paraffin/ 65degree for 1hour
  - 50 minutes
Deparaffinisation of tissue section

1. Incubate the slide for 65° for 30 mint.
2. Incubate the slide for 2 times in Xylene for 30 mint.
3. Incubate the slide for 2 times in 100% ethanol for 10 mint.
4. Incubate the slide for 2 times in 95% ethanol for 10 mint.
5. Incubate the slide for 2 times in 70% ethanol for 10 mint.
6. Incubate the slide for 2 times in 50% ethanol for 10 mint.
7. Incubate the slide for 2 times in 30% ethanol for 10 mint.
8. Incubate the slide in PBS for 5 mint.
Deparaffinisation of tissue section

9. Then add 200uL of Haemotoxylin for 5 mint.

10. Wash the slide on opposite side by running tap water.

11. Incubate the slide in PBS for 5 mint.

12. 400uL of EOSIN dye on slide

13. Wash the slide on opposite side by running tap water.

14. Incubate the slide in PBS for 5 mint.

15. Incubate the slide for 2 times in 100% ethanol for 2 mint.

16. Incubate the slide for 2 times in Xylene for 10 mint.
Microtomy of (A) Tumor with different condition, i. Control ii. Dox treatment iii. fGO@GNR-DOX
Microtomy of tumor with different section of organs treated by Dox and fGO-GNR-Dox.
References

Conclusion

GNRs reduced inherent toxicity of associated with CTAB as well as enhanced photo thermal properties of the conjugate with respect to individual ones (GNRs and GO).

Due to shape and size related properties GNRs; they are one of the best nano-materials for efficient delivery of the drugs. In short, we have combined the excellent hemodynamics of GNRs as well as high drug carrying capacity of GO for delivery of doxorubicin.

Drug release was found to be more at pH 5.8 which is mandatory for drug delivery to most of the solid tumors.

Need more study.....

Future Plan

Synthesize nanomaterial which can control pH, magnetic and photothermal property
ACKNOWLEDGEMENT