Cytotoxic effect of cobalt oxide–graphene oxide nanocomposites on melanoma cell line

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ABSTRACT
Cobalt oxide/graphene oxide (Co₃O₄/GO) nanocomposites were synthesised using the co-precipitation synthesis process. The polycrystalline nature of Co₃O₄ nanoparticles onto GO sheets is studied by X-ray diffraction (XRD) pattern where nanoparticles were found in polycrystalline nature with a particle size of 35 nm. The structural and morphological were using field emission scanning electron microscopy (FESEM) and EDX, where a distribution of Co₃O₄ nanoparticles on GO nanosheets was observed. The effect of Co₃O₄ nanoparticles on GO nanosheets was studied using a Raman spectrometer and found enhancement in the Raman peaks of GO sheets after the decoration of Co₃O₄ nanoparticles on GO nanosheets. It is observed that the I_D/I_G ratio of the D and G bands was increased from 1.08 (GO) to 1.11 (Co₃O₄/GO). In our present study, we explored the potential cytotoxic effects of Co₃O₄/GO nanocomposites in Mice melanoma cells (B16F10), where MTT assay suggested that (Co₃O₄/GO) nanocomposite shows a significant effect on cell viability compared to GO i.e. 60% cell viability was observed at 200 μg/mL of GO whereas it was only 37% for Co₃O₄/GO nanocomposite indicating improved anti-cancerous activity at this concentration. This is the first time that Co₃O₄/GO nanocomposite is tested for its cytotoxic effect and the results suggest that it can be used as an alternative source for tumour or cancer treatment.

1. Introduction
Rapidly growing cancer cases and the mortality rate is a subject of huge concern worldwide, especially in countries where population density is high and socioeconomic status is low. GLOBOCAN 2018, predicted that the number of incidences and mortality cases in 2018 was 18.1 million and estimated to be 29.5 million by 2040. Figure 1 shows the...
number of new cases and deaths reported worldwide in 2018 including both sexes and all ages [1, 2].

Medical technologies for the diagnosis and treatment of cancers have developed in past decades, still, the mortality rate is increasing which indicates the need for better treatment modalities to control this burden. In recent years, significant research has been conducted in the field of nanotechnology for its medical applications i.e. nanomedicine, including various types of nanomaterials for efficient diagnostics and treatment of cancer. Earlier, nanomaterials were used for the diagnosis of cancer and drug delivery system for cancer drugs but recently various organic and inorganic nanomaterials have been explored as anti-cancerous agents [3, 4].

Organic nanomaterials for cancer therapies (natural or synthetic polymer-formed) are liposomes, polymeric nanoparticles, polymeric micelles, dendrimers, and polymer-drug conjugates which possess excellent biological compatibility and degradability. Further, inorganic nanomaterials for cancer therapies with unique chemical and physical properties include: silica nanoparticles, carbon-based nanomaterials, nanographene, gold nanoparticles, magnetic nanoparticles and quantum dots (Table 1) adapted from [5, 6]. Among all nanomaterials metal nanoparticles have been reported for various applications such as anti-microbial [7–9] photocatalyst for wastewater treatment [10, 11] dye degradation [12], drug delivery [8], and other biomedical applications including cancers [8, 13]. Recent anti-cancerous studies of various metal and metal oxide nanoparticles have been reported.

Table 1. Types of organic and inorganic nanomaterials for cancer therapy and imaging.

| Material          | Type                             | Size (nm) | Main component | Main applications                                      |
|-------------------|----------------------------------|-----------|----------------|-------------------------------------------------------|
| Organic           | Polymeric micelles               | 20–200    | Polymer        | Therapeutic and imaging agent carrier                  |
|                   | Polymeric NPs                    | 10–1000   | Lipid          | Therapeutic and imaging agent carrier                  |
|                   | Dendrimers                       | 1–15      | Poly(amidoamine) | Therapeutic and imaging agent carrier                  |
|                   | Polymer-drug conjugates          | 5–50      | Polymer        | Drug carrier                                         |
| Inorganic         | Silica NPs                       | 20–100    | Silica         | Therapeutic and imaging agent carrier                  |
|                   | Carbon Nanotubes                 | 0.4–2     | Carbon         | Therapeutic and imaging agent carrier; photodythermal therapy |
|                   | Nanographene                     | 20–300    | Carbon         | Drug carrier; photodythermal therapy                  |
|                   | Gold NPs                         | 1–100     | Gold           | Radiotherapy; imaging; drug carrier                   |
|                   | Magnetic NPs                     | 10–50     | Iron Oxide     | Drug carrier; magnetic hyperthermia; MRI             |
|                   | Quantum dots                     | 2–100     | Metal Compound | Fluorescence imaging; photodynamic therapy; drug carrier |

*The diameter of carbon nanotubes varies from 0.4 to 2 nm for SWNTs and from 1.4 to 100 nm for MWNTs.
such as iron oxide (Fe₃O₄) nanoparticles have been demonstrated to persuade cell death and damage of DNA in human breast cancer cells [14]. Silver nanoparticles (AgNPs) (including physical, chemical, and biological) have been studied extensively for various biomedical applications including anti-cancerous properties. However, in vitro cell cultivation tests result indicated that AgNPs are toxic to several human cell lines such as immortal human keratinocytes, red blood cells, human peripheral blood mononuclear cells, liver cells, human umbilical vein endothelial cells, human bronchial epithelial cells, etc. AgNPs are known to be double-edged blade that kills microorganisms while inducing cytotoxicity in mammalian cells [15].

Toxicity and degradation of metal nanoparticles still limit their application in biological systems, therefore, formation of nanocomposites via addition of some less toxic organic or inorganic material as substrate can help in overcome this issue. In organic materials carbon-based materials namely fullerenes, carbon nanotubes and graphene are the good examples for nanocomposite substrate [16]. Among these carbon-based materials, graphene has been extensively used in fields like solar cell, sensors and capacitors due to its excellent mechanical, thermal and electronic properties [17–21]. While, the oxide form of graphene i.e. graphene oxide (GO) is the most interesting material these days and more preferred in biomedical applications due to its stability in water and biocompatibility. The layered GO sheets containing sp² hybridised carbon atoms are generated via oxidation and exfoliation of solid graphite flakes. GO sheets possess functional oxygenated groups: hydroxyl, carbonyl, carboxylic and epoxy gathering, which act to restrain electron move that makes the nuclear layer hydrophilic and extend interlayer separation [7, 22–25]. Reduced graphene oxide (RGO) sheets are generated by removal of oxygen functional groups of GO simply by reduction process, however, GO sheets preferred to be used as a progenitor for producing RGO sheets. GO sheets have been used for synthesis of nanocomposites, where different types of nanomaterials such as metallic, semiconducting and magnetic nanoparticles can be grown on these sheets with different shapes and sizes [26–28].

As an interesting study Professor Michael Lisanti and Dr Aravind Vijaya Raghavan, University of Manchester in 2015 shows that GO which is earlier used as drug delivery vehicle can itself act as anti-cancer agent. The study shows that nano sized GO can neutralise cancer stem cells while not harming other cells [www.manchester.ac.uk], the results were really interesting. However, the anti-cancerous properties of GO are lesser as compared to metal nanoparticles [29]. This motivates researchers to explore GO-metal nanocomposites as potential anti-cancerous agents where GO has been used for creating fewer toxic nanocomposites [30]. Various studies have reported application of GO and its nanocomposites as anti-cancerous agents based on the toxicological mechanism of generation reactive oxygen species (ROS) in cytotoxicity via cell-beltign down influence (i.e. cell apoptosis or cell necrosis). When nanoparticles interact with cells it brings change in the ROS production, primarily in mitochondria and affecting antioxidant defense system that induces oxidative stress. ROS formations usually includes the hydroxyl radical (OH⁻), superoxide radical (O₂⁻) and hydrogen peroxide (H₂O₂) which damages cellular components and creates events like DNA damage and ultimately apoptotic cell death. Fozia Shaheen et al., 2018 published the outcomes of the GO-ZnO nanocomposite on ROS generation via diverse doses to MCF-7 cell [31]. Similarly, Daoud Ali et al., 2018 reported inhibition of ROS production due to N-acetylcysteine and significant cytotoxic and apoptotic effect of the rGO–Ag nanocomposite in HepG2 and CHANG cells using MTT assay [32]. Table 2, shows the comparative analysis of some of the recent works on exploring anti-cancerous activities of GO based nanocomposites.
Researches are going on to develop GO nanocomposite with other metal/metal oxide nanoparticles which can be used for biomedical applications [25]. One of the emerging materials is Co3O4 nanoparticles which is studied for the potential cytotoxic and anti-cancerous effects these days. Khan et al., 2015 investigated Co3O4 in human colorectal types of cancerous cells (HT29 and SW620) and several bacteria, however, results show significant anticancer activity but no antibacterial effect [33]. Recently, the cytotoxicity and anti-cancer properties of Co3O4 nanoparticles functionalised by glutamic acid and conjugated with thiosemicarbazide have been investigated on gastric cancer (AGS) cell line, where MTT test results showed significant cytotoxic effect and anti-cancer activities and suggested its application for the drug delivery system [34]. Rauwel et al., 2020 demonstrated uptake of superparamagnetic cobalt (Co) metal nanoparticle by HCT116 and MCF7 cancer cells and DPSC mesenchymal stem cells using confocal Raman microscopy, opening new routes for cancer phototherapy [35]. MTT assay studied the toxicity of graphene based metal nanocomposites to cancerous cells may also be synergistic, which exploit

Till date Co3O4 nanoparticles have been studied for biomedical applications while nanocomposites of Co3O4/GO have studied only for their magnetic and catalytic

| S. no | Nanomaterials | Loaded volume (μg/mL) | Cell line | Cell viability (%) | Reference |
|-------|---------------|------------------------|-----------|--------------------|-----------|
| 1.    | GO-ZnO        | 10                     | MCF-7 cells | 90                | Fozia Shaheen et al., 2018 |
|       |               | 20                     |           | 79                |           |
|       |               | 40                     |           | 62                |           |
|       |               | 60                     |           | 55                |           |
|       |               | 80                     |           | 47                |           |
|       |               | 100                    |           | 37                |           |
| 2.    | rGO–Ag        | 5                      | CHANG cells | 96                | Daoud Ali et al., 2018 |
|       |               | 10                     |           | 84.9              |           |
|       |               | 25                     |           | 68.6              |           |
|       |               | 50                     |           | 35                |           |
|       |               | 5                      | HepG2 cells | 92                |           |
|       |               | 10                     |           | 78                |           |
|       |               | 25                     |           | 42.9              |           |
|       |               | 50                     |           | 23                |           |
| 3.    | AgNPs (Inhibition percent) | 0 | HGF cell line | 0.00 | Kiran R. Halkai et al., 2018 |
|       |               | 8                      |           | 2.11              |           |
|       |               | 16                     |           | 3.34              |           |
|       |               | 32                     |           | 5.10              |           |
|       |               | 64                     |           | 10.32             |           |
|       |               | 128                    |           | 27.23             |           |
|       |               | 256                    |           | 46.36             |           |
|       |               | 512                    |           | 65.24             |           |
| 4.    | Iron oxide (after 24h) (after 48h) | 10 | MCF-7 cells | 99 | Saud Alarifi et al., 2018 |
|       |               | 30                     |           | 84                |           |
|       |               | 60                     |           | 67.4              |           |
|       |               | 120                    |           | 46.9              |           |
|       |               | 10                     | MCF-7 cells | 98.6              | Saud Alarifi et al., 2018 |
|       |               | 30                     |           | 70                |           |
|       |               | 60                     |           | 57.8              |           |
|       |               | 120                    |           | 39                |           |
| 5.    | CuO–RGO       | 5                      | L-929     | 85                | Xiangyang Xu et al., 2018 |
|       |               | 10                     |           | 78                |           |
|       |               | 25                     |           | 65                |           |
|       |               | 50                     |           | 50                |           |
|       |               | 100                    |           | 25                |           |
| 6.    | Co3O4/GO      | 10                     | B16F10    | 82                | Present study |
|       |               | 50                     |           | 58                |           |
|       |               | 100                    |           | 47                |           |
|       |               | 200                    |           | 37                |           |
properties [36–37]. Therefore, in the present work cytotoxic properties of Co$_3$O$_4$/GO nanocomposite are explored. Here, GO is synthesised by using modified Hummer’s method and the GO nanosheets are decorated with Co$_3$O$_4$ nanoparticles by co-precipitation method. Well characterised Co$_3$O$_4$/GO nanocomposites were used for study of cytotoxicity on Mice melanoma cells (B16F10) via MTT assay.

2. Experimental section

2.1. Material

For synthesis of GO and Co$_3$O$_4$/GO nanocomposites different chemicals and reagents were used. Graphite flakes (99.8%, 325 mesh) were obtained from Alfa Aesar and hydrazine hydrate ($\text{NH}_2\text{NH}_2$) from Sigma-Aldrich. Sulphuric acid ($\text{H}_2\text{SO}_4$), potassium permanaganate ($\text{KMnO}_4$), sodium nitrate ($\text{NaNO}_3$), hydrogen peroxide ($\text{H}_2\text{O}_2$), ethanol ($\text{CH}_3\text{CH}_2\text{OH}$), hydrochloric acid ($\text{HCl}$), cobalt acetate tetrahydrate ($\text{Co(C}_2\text{H}_3\text{O}_2)\text{2.4H}_2\text{O}$) and double distilled water ($\text{H}_2\text{O}$) were obtained from Merck. All chemicals were used without further purification.

RPMI-1640, FBS, Antibiotics were purchased from Himedia Laboratories Pvt. Ltd. Mumbai- 400086, India. Mice melanoma cells (B16F10) was obtained from National Centre for Cell Science, Department of Biotechnology, Pune, India. Cells were grown as monolayer in RPMI-1640 medium, supplemented with 10% (v/v) FBS, antibiotics (penicillin 100 U/mL, streptomycin 10 $\mu$g/mL) and 1 mmol/L sodium pyruvate under standard conditions (37°C) in a controlled humidified atmosphere containing 5% CO$_2$.

2.2. Synthesis of graphene oxide (GO) sheets

Graphene oxide (GO) sheets were synthesised by modified Hummers method from expanded acid washed graphite flakes. In typical synthesis procedure, 2 g of sodium nitrate was added to 50 mL of sulphuric acid followed and the mixture was stirred for 30 min at 80°C. In this mixture, 2 g of graphite powder was added under continuous stirring for 50 min at 70°C. Further, the mixture was kept below 5°C in the ice bath, and 12 g of potassium permanganate was slowly added into the mixture. The temperature of mixture was allowed to rise to 40°C and the mixture was continuous stirred for another 6 h until it became a viscous reddish-brown paste. After stirring, 100 mL of double distilled water was slowly added to the mixture and the mixture was kept at 95°C for another 1 h. Finally, 180 mL of hot double distilled water and 10 mL of 5% hydrogen peroxide solution were added to the mixture to stop the reaction. The residual metal ions were removed after the process of mixing by centrifugation and the precipitate was washed several times with 10% hydrochloric acid solution. The precipitate was dried at 50°C under a vacuum condition and GO sheets were obtained.

2.2. Synthesis of Co$_3$O$_4$/GO nanocomposites

Nanocomposites of Co$_3$O$_4$ and reduced graphene oxide were successfully synthesised by co-precipitation method. Firstly, GO (100 mg) was dissolved into 80 mL in alcohol through sonication for 5 h. In the meantime, a fixed amount of Co ($\text{NO}_3$)$_2$6$\text{H}_2\text{O}$ (300 mg) was dispersed into another 50 mL in alcohol. The mixture was magnetically stirred for 5 h. Afterthought the resulting solution was heated to 150°C under reflux and
vigorous magnetic stirring for 15 h. After that the system was cooled to room temperature. Finally, the obtained solution was centrifuged, washed with absolute ethanol and water many times and dried in a vacuum oven at 50°C for 24 h. The obtained solid product was labelled Co₃O₄/GO nanocomposites. The schematic diagram of synthesis process of Co₃O₄/GO nanocomposites is given in Figure 2.

2.3. Characterisation of nanomaterial

The GO and Co₃O₄/GO nanocomposites were characterised by different experimental techniques. For crystalline nature study, the X-ray diffraction pattern of nanocomposites was analysed using X-ray diffractometer from Panalytical. The surface morphology of these samples was analysed by scanning electron microscopy (Care-Zeiss EVO-40, working voltage 20 kV, Germany) and EDAX setup is inbuilt in SEM. The structure of GO and particles size distribution of Co₃O₄ NPs on GO sheets were studied using transmission electron microscopy (Zeiss EVO ED15), where accelerating potential was set as 200 keV. Raman spectra of GO and Co₃O₄/GO nanocomposites were recorded by using Raman spectrometer (HORIBA Xplora), where excitation source was 514 nm Ar-ion laser.

2.4. Cell viability by MTT assay

B16F10 5000 cells/well were seeded in a 96-well plate and after attachment the fresh medium having different concentrations of GO (100–500 μg/mL) added to the wells. The cells were allowed to grow for further 24 h. After completion of incubation, 20 μL of MTT (5 mg/mL in PBS) was added into each well and incubated further for 3 h and media was removed and 200 μL of DMSO was added to each well. The cells were again incubated for another 5–10 min at room temperature. The purple colour thus developed was measured at 595.
3. Result and discussion

3.1. XRD Studies

The phase formation of the Co$_3$O$_4$/GO nanocomposites, were confirmed by XRD spectrum (Figure 3). The data were collected between scattering angle ($2\theta$) from $10^\circ$ to $70^\circ$ at scanning rate of $5^\circ$ min$^{-1}$. XRD pattern of Co$_3$O$_4$/GO nanocomposites shows the characteristics peak at $37.3^\circ$, which indicates the polycrystalline nature and particle size of Co$_3$O$_4$ nanoparticles whereas, other XRD peaks appeared at $18.8^\circ$ (111), $30.4^\circ$ (220), $37.3^\circ$ (311), $43.1^\circ$ (400), $54.3^\circ$ (422), $57.1^\circ$ (511) and $62.6^\circ$ (440)$^{38}$. These XRD peaks indicate the ultra-fine nature and small polycrystalline size of Co$_3$O$_4$.

The average particle size of magnetic Co$_3$O$_4$ nanoparticles is calculated by using the Debye–Scherrer's formula $^{39}$.

$$d = \frac{K \lambda}{\beta \cos \theta}$$  \hspace{1cm} (1)

where $d$ is grain size, $\lambda$ is X-rays wavelength, $\beta$ is full width at half maximum (FWHM) of diffraction peak (in radian), and $\theta$ is Bragg’s diffraction angle (in degree). The average particle size of Co$_3$O$_4$ nanoparticles decorated onto GO was found to be 35 nm which was evaluated from the line broadening of the (311) peak using Debye–Scherrer's formula. Peaks of Co$_3$O$_4$/GO nanocomposites shows that presence of all pure form with observable shifting $^{38}$. XRD analysis of GO (Figure 3 Inset) also reveals that graphite powder has completely oxidised into graphene oxide as confirmed by peak observed at 11.3 (001) $^{25}$.

3.2. SEM and EDX analysis

The surface morphology studies of GO nano sheets and Co$_3$O$_4$/GO nanocomposites were carried out using FESEM. The crumpled sheets like structure in Figure 4(a) confirms GO while irregular spherical structures deposited onto GO sheets in Figure 4(b) attributed to

![Figure 3. XRD pattern of Co$_3$O$_4$/GO nanocomposites and inset picture is given for the GO nanosheets.](image-url)
formation of Co$_3$O$_4$ nanoparticles on GO nanosheets [40]. Elemental analysis confirms the presence of the targeted material of nanocomposite, here, EDX spectrum of GO and Co$_3$O$_4$/GO nanocomposite is shown in Figure 4(c) and (d), respectively. EDX spectrum of Co$_3$O$_4$/GO nanocomposites confirms the presence of cobalt. EDX shows the presence of all elements CO, O and C particles with red, green, and pink colours, respectively and no foreign atom is obtained. Si peak arises due to silicon substrate.

3.3. Raman analysis

The degree of graphitisation was evaluated using Raman spectra, where main features of GO nano-sheets are the position and intensity of D and G peaks. In case of carbon-based materials, the higher ratio of intensity (I_D/I_G) corresponds to a lower degree of graphitisation [41]. Figure 5 depicts the Raman spectra of GO nanosheets and Co$_3$O$_4$/GO nanocomposites. The position of D, G, 2D and D+G bands were obtained at 1341, 1594, 2670 and 2961 cm$^{-1}$, respectively. Raman spectra of Co$_3$O$_4$/GO nanocomposites show slight shift in Raman peak position of D and G band relative to GO nanosheets. The D peak and G bands were slightly shifted from 1341 to 1339 cm$^{-1}$ and 1594 to 1597 cm$^{-1}$, while 2D and D+G bands were shifted from 2670 to 2675 cm$^{-1}$ and 2961 to 2963 cm$^{-1}$ respectively, signifying the possible charge transfer between the GO nanosheets and Co$_3$O$_4$ nanoparticles. It is well reported that highly disordered graphene shows a broaden
G band and a relatively intense D band. The intensity ratio of the D and G peak ($I_D/I_G$) was used to evaluate the disordered crystal structure of carbon-based materials. The values of $I_D/I_G$ for GO nanosheets and Co$_3$O$_4$/GO nanocomposites clearly shows that $I_D/I_G$ ratio of the D and G bands was significantly increased from 1.08 (GO) to 1.11 (Co$_3$O$_4$/GO) after the synthesis process [42, 43].

3.4. Morphological study of cell line and MTT assay

Then, cell viability test was performed using MTT assay for which mice melanoma cells (B16F10) were seeded in a 96-well plate. Firstly, changes in morphology of cell line was observed via seeding equal number of cells in the 6 well plates (i.e. 5000 cells per well). After proper attachment of the cells the RPMI-1640 medium is discarded and the fresh RPMI-1640 medium with different concentrations of GO and Co$_3$O$_4$/GO (10–200 $\mu$g/mL) added to the wells. The cells were allowed to grow for further 24 h then post treatment, cells were fixed in fixative solution and stained with crystal violet solution [30, 44]. The excess stain was washed and images of cells were captured under inverted microscope (Nikon ECLIPSE Ti-S, Tokyo, Japan), at $10\times$ magnification. The images of treated cells are shown in Figure 6.

Similarly, next cell samples were seeded, washed and incubated for 24 h with different concentrations of GO and Co$_3$O$_4$/GO (10–200 $\mu$g/mL). After completion of incubation, 20 $\mu$L of MTT (5 mg/mL in PBS) was added into each well and incubated further for 3 h, then media was removed and 200 $\mu$L of DMSO was added to each well. The cells were again incubated for another 5–10 min at room temperature and after the development of the purple colour the absorbance was measured at 595 nm using a microplate reader. The cytotoxicity of the pure GO was dose dependent i.e. the viability of B16F10 cells is decreased with increased dose of GO. Figure 7(a) shows 60% cell viability was observed at 200 $\mu$g/mL of GO whereas Figure 7(b) shows that at 200 $\mu$g/mL of Co$_3$O$_4$/GO nanocomposite the viability of cells was only 37% indicating improved anti-cancerous activity [31, 45]. This cell viability study suggests that GO possess anti-cancerous properties but integration of Co$_3$O$_4$ nanoparticles onto GO generates a nanocomposite possessing
remarkable anti-cancer activity. In case of Co$_3$O$_4$/GO nanocomposite GO and Co$_3$O$_4$ synergistically inhibit cell aggregation and the death of cancer cells occur because of free radical production by Co$_3$O$_4$ [30, 46]. In addition to altering cell morphology, Co$_3$O$_4$/GO nanocomposite decreases metabolic activity in cells, increases oxidative stress, damaging mitochondria, and ultimately damaging DNA by producing reactive oxygen species [45, 47–50]. Table 2, shows comparative analysis of synthesised material with other reported materials for their anti-cancerous activities [30, 31, 34, 44, 46, 47].
4. Conclusion

Co$_3$O$_4$/GO nanocomposites were synthesised using simple co-precipitation method, characterised and used for anti-cancer activity studies in mice melanoma cell line. Cobalt oxide nanoparticles have been reported for good anti-cancerous activity but it has high cell toxicity also, which limits its direct application in health care. While GO is reported for its mild anti-cancer activity but good biocompatibility. Addition of GO offer biocompatibility and lesser the toxicity of cobalt oxide nanoparticles while maintaining its anti-cancerous activity. Here, synergistic effect of GO and Co$_3$O$_4$ generate anti-cancerous activities by producing ROS which results in increased oxidative stress, damaging mitochondria, damaging DNA and finally death of cancer cell. This is the first study of using Co$_3$O$_4$/GO nanocomposite as anti-cancerous agents where results suggested that the nanocomposite shows significant cytotoxic effect and can be used as an alternative source for tumour or cancer treatment. However, the detailed molecular mechanism underlying cytotoxic effect of Co$_3$O$_4$/GO nanocomposites needs to be studied. This study can play an important role for its applications as cancer treatment and medicals etc.

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Disclosure statement

The authors report there are no competing interests to declare.

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Data availability

The data that supports the findings of this study are available within the article.

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