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Photocatalytic, degradation, sensing of Pb^{2+} using titanium nanoparticles synthesized via plant extract of Cissusquadrangularis: In-vitroanalysis of microbial and anti-cancer activities

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ABSTRACT

The green synthesis of Titanium and Ti- Cerium nanoparticle (Ti-CeNP) is a convenient rapid and eco-friendly method compared to traditional synthesis methods. The green plant extract was synthesized from Cissusquadrangularis (CQ).The TiO_2 and Ti-Ce nanoparticles were examined by UV, XRD,FTIR.SEM. The SEM analysis shows the size and shape moropology of TiO_2 and Ti-Ce nanoparticles.The synthesized TiO_2 and Ti-Ce nanoparticles were confirmed by UV in the range occur at 350 and 500 nm The maximum zone of inhibition was observed in the synthesized TiO_2NPs against Bacillus subtilis (60 mm).The green synthesized TiO_2 and Ti-Ce using Cissusquadrangularis plant extract exhibited strong antibacterial activity, sensing Pb^{2+} ion and photo catalytic degradation of methylene blue dye.The Cytotoxicity of titanium nanoparticles was studied in MCF-7 cell lines using MTT assay. The results shows that the nanoparticles exhibits good results can satisfy the requirement of industrial production bearing the advantage of low cost,reproducible and eco-friendly.The green synthesized TiO_2NPs has potential for use in the treatment for medical applications.

1. Introduction

Nanotechnology is a branch of science concerned with ranging from 1–100 nm to at least one dimension. Organic and inorganic materials are categorized into nanomaterials [1]. Titanium dioxide (TiO_2) is a naturally abundant metal oxide. TiO_2NPs are white semiconductors with high thermal stability, excellent optical and dielectric properties, biocompatibility and non-toxicity [2,3]. At different temperatures, it can exhibit three different phase in nano range, such as Anatase, Rutile, and Brookite. Anatase has been shown to have excellent chemical and physical properties for environmental remediation between these stages [4]. Nanoparticles of Titanium dioxide also show distinct surface chemistry and morphologies.The synthesis of tin, textiles, sheets, plastics, cosmetics and foodstuffs [5]. For the degradation of toxic chemicals in water, colloidal TiO_2 NPs was used by Centi et al. [6]. The titanium dioxide was synthesized by using different techniques such as solution preparation, solvothermal synthesis, polyol reaction, sol-gel reaction, Titanium dioxide has a greater advantage because of its low toxicity, biocompatibility, chemical and thermal stability [7–9]. In the synthesis of nanoparticles, extracts from the plant can act as both reductants and stabilization of agents.The source of the plant extract is believed to impact the characteristics of the nanoparticles [10].This is because various concentrations and variations of organic reducing agents are present in different extracts [11]. Theresearchers' current interest is due to the increasing microbial resistance to metal ions, antibiotics and the production of resistant strains [12]. TiO_2 NPs contain established noteworthy sterile activity [13] that TiO_2 generates reactive oxygen species has been investigated as an anti-cancer agent when exposed to ultraviolet radiation, nanoparticulate TiO_2 used in antibacterial coatings and wastewater disinfection [14]. Green approach is environmentally responsive, cost-effective, biocompatible and healthy [15]. Nanoparticles prepared from this process produce more catalytic activity and reduce the use of expensive and toxic chemicals. The synthesis of nanoparticles using a green approach has greater than before in recent years [16]. For practical applications, the photocatalyst must be dynamic under UV and light under solar light. The measurement of photocatalytic motion under replicated sun-powered light or UV–vis illumination is another research subject.

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[17]. Lots of novel nanomaterials are being developed by the researchers for identifying novel properties and applications. Nanomaterials are usually synthesized by utilizing smart techniques that comprise the usage of hazardous solvents and toxic chemicals like pyrolysis, sol-gel technique, chemical vapour deposition, etching etc., and supercritical fluid [18]. However, TiO_2NPs induce difficult effects on human cells and tissue; hence, their use as antibacterial agents remains under limitation. Doping with Au, Ag, Pt, or Ag, can narrow the band gap of TiO_2NPs and enhance its photocatalytic effect [19,20]. The aim of the present study was to investigate the sensing,degradation and antibacterial, anticancer activities.

2. Materials and methods

2.1. Materials

The chemicals and reagents that are used for synthesis of Titanium and Ti- Cerium nanoparticle. Titanium dioxide,Cerium Nitrate were the analytical grade from Merck India Ltd. Double-distilled water was used to prepare all the solutions. The fresh Cissusquadrangularis(Cq) leaf was collected in and around Tiruchirappalli district, Tamilnadu, India.

2.2. Preparation of leaf extract

100 mg of CQ leaf was boiled with 100 mL of deionized water at 90 °C for 15 min and the extract was filtered twice using Whatmann filter paper no.1. The filtrate was collected in a 250 ml standard flask and then placed at 40 °C for further experiments in the refrigerator.

Phytochemical analysis of Cissusquadrangularis leaves

S. No	Phytoconstituents	Aqueous leafextract
1	Flavonoids	+
2	Carbohydrates	+
3	Steroids	+
4	Terpenoid	+
5	Tannins	–
6	Phenolic compounds	+
8	Alkaloids	+
9	Gums and mucilage	–
10	Glycosides	–
11	Saponins	–
12	Protein and amino acids	+

2.3. Synthesis of Titanium nanoparticles

Controlled Synthesis of TiO_2NPs, 0.01 mM Titanium dioxide aqueous solution was prepared for the synthesis of Titanium nanoparticles. 25 ml of prepared leaf extract was added to TiO_2 solution. The pale yellow colour solution becomes deeper brown in 60 min. which stands as a preliminary conformation of the formation of Titanium nanoparticles. The synthesized TiO_2NPs were collected for 15 minutes at 2000 rpm by centrifugation and then the filtrate was dispersed in water and centrifuged multiple times to extract any excess organic moieties. Finally, the green synthesized TiO_2NPs were stored at 4 °C before use.The TiO_2NPs described in the present study is found to be stable for more than three months. The Titanium dioxide in the aqueous medium forms the Titanium ions. When it is added to the leaf extract, the Titanium dioxide ion attacks the Hydroxyl groups of the bio active compounds. The free electron formed ‘during this process reduces the Titanium.

2.4. Synthesis of Ti-Ce nanoparticles

Cissusquadrangularis plant extract of 30 ml added with 0.5 mM TiO_2 and 0.01 N 10 ml of Cerium nitrate. The solution was taken in a beaker for 20 min and magnetic stirrer up to15 min. The solution becomes White & light yellowish colour precipitate. After this solution was filtered and dried. Finally the synthesized Ti-Ce nanoparticles were formed.

2.5. Colorimetric sensing of Pb^{2+}

The different concentrations of Pb^{2+} ions were useful to TiO_2−NPs using green synthesised colloidal TiO_2−NPs dispersion. The sensitivity of TiO_2NPs, emblematic alkali(Li^+,Na^+,K^+), alkalineearth (Mg^{2+},Ca^{2+}) and transition metal ions (Mn^{2+},Ni^{2+},Cu^{2+},Cd^{2+},Co^{2+},$Hg^{2+}$$As^{2+}$) The identicalsituation were analysed and the equivalent concentrations were added to the Ti-NPs solution,.

2.6. Photocatalytic measurement

For the photocatalytic activity, photocatalytic measurements for the TiO_2−NPs for Methylene blue dye were used. The suspension of 100 ml of 10 mg/l Methylene blue dye solution spectroscopy was consistent with the medium quantity of 100 mg samples in the catalytic experiment. In the dark after being spread in an ultrasonic bath for 5 to 15 min to enter the desorption processes of adsorption. The suspension was then subjected to intense irradiation from sunlight. At precise time intervals, the samples were obtained and The concentration of the colourant was resolved using UV–Vis [21].

2.7. Antibacterial assay

The agar well diffusion method against the Gram-negative bacteria of Escherichia coli and Gram-positive bacteria of Bacillus subtilis, Streptococcus pneumoniae, Staphylococcus aureus test was assayed by the antibacterial analysis of TiO_2 NPs determined by chemical and green synthesis method. The media plates (NA) were streaked with bacteria 23 times by rotating the plate at 60° angles for each strip to ensure the homogeneous distribution of the inogeneous distribution. At varying concentrations of 20–100 μg/ml, six-millimetre thick sterile discs were impregnated with 10 μl of Ti sample respectively. The prepared discs were placed on the top layer of agar plates and left for compound diffusion at room temperature for 30 min. Adverse control using the respective solvent was prepared. The plates were incubated at 37 °C for 24 h, and the inhibition zone was registered [22].

2.8. MTT assay

The sample of Titanium was tested for in vitro cytotoxicity using 3-(4,5-Di-methyl-thiazol-2-yl)-2,5-Di-phenyl-tetrazolium bromide (MTT) assays using MCF7 cells. The 15 ml tube, was used to harvest the cultivated MCF7 cells.The cells were then put in a DMEM medium at a thickness of 1 to 105 cells (200 μL) into a 96-well tissue culture plate. 10 percent FBS and 1 percent solution of antibiotic at 37 °C for 2448 h. The wells were washed with sterile PBS and processed in a serum free DMEM medium with varying concentrations of the TI sample. All sample was three times frequent and the cells were incubated for 24 h at 37 C in a humidified 5 percent CO_2 incubator. 20 μL of 5 mg/ml of MTT was applied to each well after the incubation time and the cells incubated for another 2–4 h before purple colour precipitates were formed. An inverted microscope, it is clearly visible. Eventually, along with MTT (220 μL), the medium was collected from the wells and cleaned

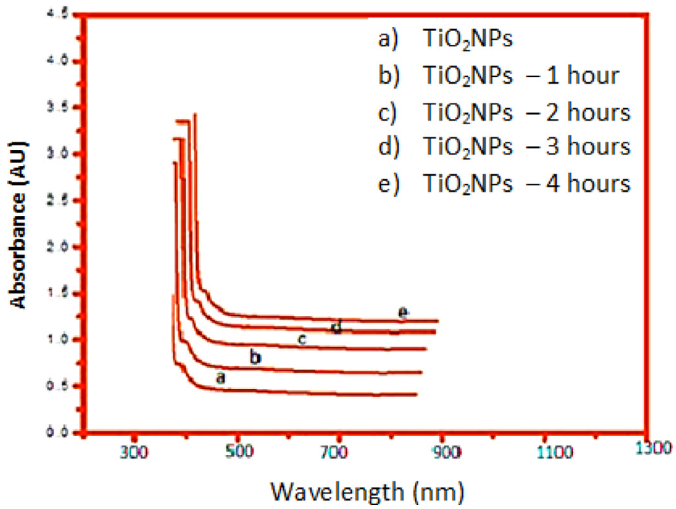

Fig. 1. UV-visible spectrum of different time intervals of green synthesis of Titanium nanopatrticles using Cissus quadrangularis leaf extract mediated synthesized Titanium nanoparticles.

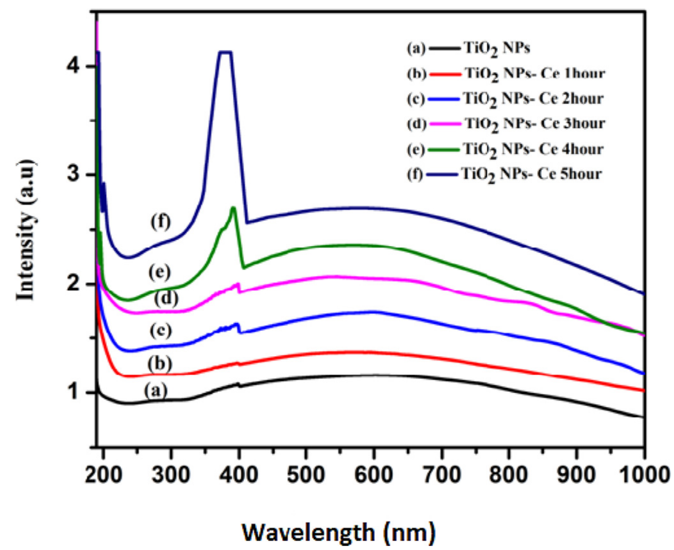

Fig. 2. UV-visible spectrum of different time intervals of green synthesis of Titanium nanopatrticles doped with cerium using Cissus quadrangularis leaf extract mediated synthesized Titanium nanoparticles.

with 1X PBS- (200 μl). Additionally, DMSO (100 μL) was applied to dissolve formazan crystals and the plate was shaken for 5 min. Using a micro plate reader (Thermo Fisher Science, USA), the absorbence for each well was measured at 570 nm and the percent cell viability and value of IC50 was determined using Graph Pad Prism 6.0 software (USA)

3. Results and discussion

3.1. UV–visible spectral analysis

The synthesised nanoparticles are Ti in nature. The development of colour from pale yellow to deep brown due to the reduction of titanium by the presence of reducing agents in Cissusquadrangiularis aqueous extract as shown in Fig. 1. In the range of 350 to 400 nm, the peak of UV absorption occurs. Metal nanoparticles have free electrons that give Plasmon resonance on the surface occurred in the visible range [22,23]. The UV vis spectra also showed that TiO_2NPs were rapidly acquired and the TiO_2NPs in solution remained stable even after 24 h of completion reaction. Ultraviolet visible spectrometry was developed. Used in aqueous suspension to investigate the shape and size of the nanoparticles. The aqueous leaf extracts worked as reduction and capping agents. By mixing biomolecules present in these extracts, including enzymes/proteins, amino acids, polysaccharides and vitamins, the removal of titanium ions is pollution-free, but chemically complex. The process is however, generally accepted for green Titanium synthesis, and nanoparticles of gold in the occurrence of the enzyme nitrate reductase. The effect of the inclusion of different quantities of dried biomass on the degree of bio reduction and consistency of the target products was studied using aqueous titanium oxide (10 mL, 1 mM). It has been found that the amount of dried biomass acting a critical role in the distribution of titanium nanoparticles in terms of size. The absorption spectra formed in titanium nanoparticles are shown in Fig. 1.Diffrent time intervals show that these nanoparticles were formed within one hour of the biomass coming into contact with the titanium ions. After adding the biomass to the Titanium oxide solution, the solution changed from white to yellow in around an hour, deepening the final colour by increasing the amount of dried biomass. The evolution over time of the absorbence spectra emanating from the nanoparticles of Titanium showed at about 370 nm, increasingly sharp absorbence with increasing reaction time. Saponins and phenolic compounds present in plant extracts bind to nanoparticles in protein To conclude, quinones, phenolic compounds, and saponins are water soluble. A colour change was observed. Titanium oxide ions to Titanium nanoparticles when exposed to the plant leaf extract during the bio reduction of titanium ions. At different time intervals, ultraviolet visible spectra were reported for the reaction with after thirty minutes of reaction, the aqueous Titanium oxide solution showed the presence of a surface plasmon resonance band at around 370 nm. The resonance band rises sharply from 30 to 180 min. It is evident from Fig. 1 that the peak wavelength during the reaction did not change. Thus by measuring absorbence at 370 nm shown in Fig. 2.for the Titanium dioxide. Doped nanoparticles with cerium nitrate using the Cissusquadrangularis leaf extract green synthesis. From one hour to four hours, the band rises dramatically. Using UV-Visible spectra analysis, the formation of Titanium and cerium nano particles was reported. Free electrons from TiO_2–NPs and Ce NPs give rise to a suface plasmon resonance abortion band due to the combined electron vibration of metal nanoparticles in resonance with the light wave surface plasmon resonance spectra for Ti-Ce NPs acquired at 380 nm, which appeared white in colour [24].

3.2. Surface morphology analysis (SEM)

TiO_2 NPs:

The scanning electron microscopy of the as synthesised (TiO_2NPs) via green approach at various magnifications shows irregular and angular nanostructure in Fig. 3(a and b). It shows that the TiO_2NPs have different shapes and size which is 4–5 nm. have been obtained using leaf extract that is used as a capping and a reducing agent [25].

Ti –Ce:

The morphology of the titanium and cerium nanoparticles was observed according to the Scanning electron microscopy, rod and spherical in which titanium and cerium nanoparticles are aggregated in Fig. 3(c and d).The above findings indicated that the titanium and cerium nanoparticles are synthesised due to the action of plant extract (CQ) acting as a strong bio-reducing agent for biosynthesis [26]

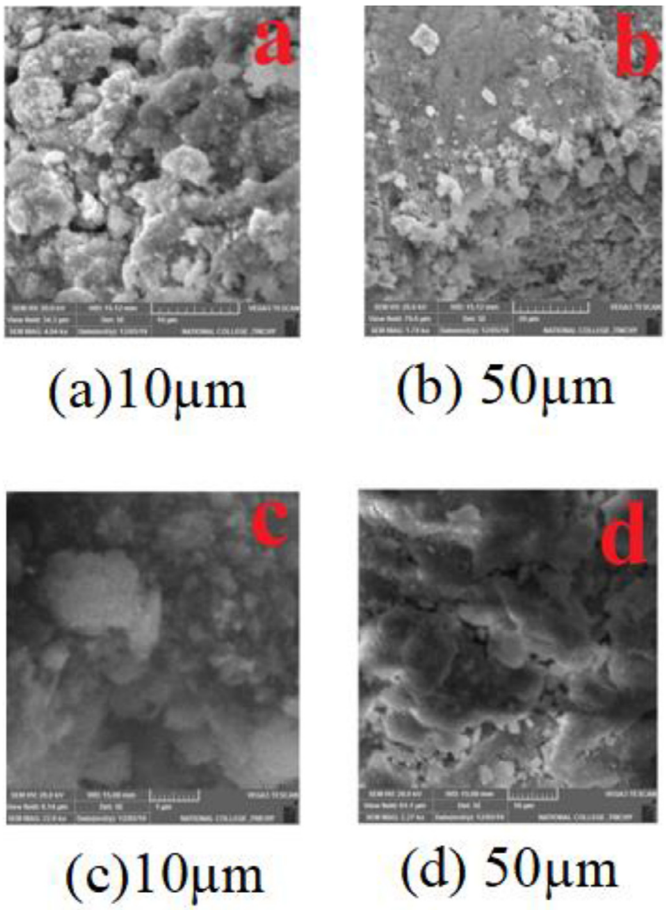

Fig. 3. (a and b) SEM image of TiO_2 NPs (c and d) Ti –Ce NPs.

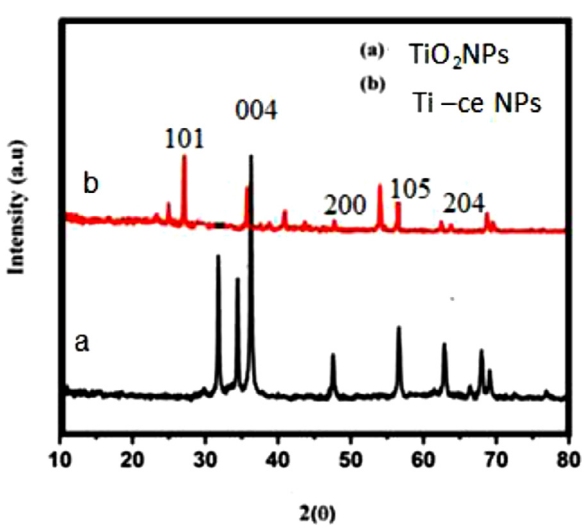

Fig. 4. XRD spectrum of (a) TiO_2NPs (b) Ti-Ce NPs.

3.3. X-ray diffraction analysis (XRD)

XRD tests to check the crystal and nano structural of Titanium and Ti-Ce. The XRD pattern of Titanium nanoparticles is shown in Fig. 4(a) at optimal conditions. This shows four sharp peaks at 2 values. At 2θ ranges of 26,35.2,47.1,58.2&64.8,four major peaks have been found with clear planes of [101], [004], [200], [105], [204] for Titanium, respectively JCPDS.Card no:21-1272. It is evident that nanoparticles of TiO_2 have a mixture of anatase and rutile phases [27]. The observed nanoparticles of TiO_2NPs indicate that the purity of the samples was clearly demonstrated by different peaks linked to the purity of TiO_2NPs [23]. Fig. 4(b)Displays the XRD patterns obtained from the plant extract of Ti and Ce nanoparticles. Prominent Bragg relections were found from the XRD patterns at 2θ values of 32 and 46.It is obvious that diffraction can be represented in terms of a crystal structure in which Ce molecules have been frequently staggered with a lattice dimension layer. It is observed corresponding to (120) and (132).

3.4. FT-IR spectroscopy

The mixture of TiO $_2$NPs and cissusquadrangularis extract was analysed using FTIR to confirm the formation of TiO_2NPs. The peaks of absorption were observed at 3400, 2918, 2917, 1383,1081 and 695 cm^1. For stretching and bending vibrations of water molecules present on the surface of the NPs, peaks at 3400cm-1 were allocated. N–H, C=O groups were attributed to the vibration bands near 2918 and 2917cm-1, suggesting the presence of fatty acids, carbohydrates,Protein. For C=C and C=C, the vibration bands centred at 1383 and 1081 cm-1 were assigned to CO groups of lingo cellulose groups of aromatic and characteristic bands in Cq extract, respectively. Ti-O and Ti-Ce respectively reflect the peaks obtained below 695 cm-1. The findings, however, indicated that the existence of feature groups associated with the extract of Cissusquadrangularis was found in Ti NPs [28].

3.5. Photocatalytic degradation

Using green synthesised titanium nanoparticles under solar light, the photocatalytic degradation of methylene blue was conceded out. Initially, dye degradation was defined by colour shift. Initially, the colour of the dye reveals that after 20 min of incubation, the deep blue colour shifted to colourless between the time interval from (0 to 5, 10, 15 20,25,30 min) When exposed to solar light with titanium nanoparticles.. Finally, at 20 min, the degradation method was completed, which is the equilibrium status obtained. Initially, the adsorption of Ti nanoparticles to the methylene blue solution was low and further increased with a steady rise in time and dye degradation percentage. Overall due to excitation, the photo catalytic properties of Ti nanoparticles in visible light may be fine.Surface Plasmon Resonance, however, greater aggregation may also have been caused at the same time by more photo catalyst, resulting in a decrease in the photo surface catalyst's area, rendering a large fraction of the catalyst inaccessible to the dye adsorption.

3.6. Mechanism of photocatalytic activity

The electrons or holes that moved to the active Ti surface of the mixture. To understand the mechanism of photocatalytic operation, the nanostructure directly joins the redox reactions, the electon reduce the dissolved oxygen to reproduce superoxide anion ($\bullet O_2$), while oxidizing molecular H_2O to produce hydroxyl radicals ($\bullet OH$). Organic dye contaminants are gradually oxidised into CO_2 and H_2O products by these highly bouncing organisms.

3.7. Sensing of Pb^{2+}

There are some benefits to the colorimetric process more than new approaches for the purpose of poisonous heavy metal ions. The nano characteristics are presently considered needed for efficient applications of metal and ion sensors. The colorimetric responses of the synthesis of Titanium NPs regulated by size and shape can be studied here. Pb^{2+}ion was chosen as the target

Table 1
Antibacterial activity of synthesized TiO_2 NPs against (a). S. aureus, (b) Bacillus subtilis, (c) streptococus pneumoniae and (d) E. coli bacteria.

Bacteria name	25 (mm)	50 (mm)	75 (mm)	100 (mm)
S. aureus	9 ± 1.0	9.5 ± 1.2	10 ± 0.5	9 0.5 ± 1.0
S. pneumoniae	10± 0.5	9 ± 1.0	12± 1.0	10 ± 1.0
B.subtilis	11± 1.0	10± 0.5	12 ± 1.0	11± 0.5
E. coli	10 ± 1.0	9 ± 0.5	10 ± 1.0	10 ± 1.0

molecule for from a sensor. In particular, due to an extreme degree of isotropy in the localized Surface Plasmon Resonance (SPR), the intentionally engineered nanocomposites display exquisite features in the localised SPR. A large range of potential applications are promising in their structure, including not only imaging and catalysis, but also chemical and biological colorimetric sensing. Such engineered TiO_2NPs can therefore serve as excellent building blocks for test construction when their SPR shifts in response to a metal ion. TiO_2NPs s is well known to show a dark brown colouring solution due to 370 nm band of SPR excitation. By adding heavy metal ions such as Mn^{2+}, Fe^{3+}, Co^{2+}, Ni^{2+}, Zn^{2+}, Hg^{+}, Cd2+, Bi^{2+} and $As^{3+}$to an aqueous solution, the selectivity of the nanocapsules was assessed. Interestingly, TiO_2NPs s are selectively decolorized from white to colourless by the addition of Pb^{2+} ions (Fig. 8), although There is a marginal change in the colour of TiO_2NPs in other metal ions and there is no significant peak SPR shift observed as shown in Fig. 8. There are also no major improvements in the addition of regular metal ions and some anions, such as Al^{3+}, Cr^{3+}, -, $PO_4{}^{3-}$, NO^{3-}, NO^{2-} and $Cr_2O_7{}^{2-}$. After the addition of only Pb^{2+} ions, the absorption band of TiO_2NPs at 370 nm selectively disappears, as shown in Fig. 8. To obtain further data on the vulnerability of TiO_2NPs The UV Visible colour changes are observed for respective spectral lines. The direct redox reaction between Ti^0 and Pb^{2+} ions, where TiO_2NPs are oxidised to form Ti^{+} and Pb^{2+} ions are reduced to Pb^{2+}. The synthesized TiO_2NPs by carboxyl and amino, phenolic groups current in the extract plays an chief role in the creation of ligands. It is assumed that One end of the carboxyl and amino, phenolic groups present in Ti chemisorbed Cissusquadrangularis results in high TiO_2NPs stability, while the other end binds to Pb^{2+} by TiO_2NPsleaching.products by these highly bouncing organisms.

The photo-constituent functionalities reported in the present study play a key role in the non-aggregation of nanoparticles, benefiting the sensor system with high sensitivity and selectivity properties. The mechanism of sensing for the identification of Pb^{2+} ions in the green synthesised TiO_2–NPs probe is shown in Fig. 8.

3.8. Antimicrobial activivty

Antibacterial activity of samples TiO_2 NPs:

Titanium nanoparticles synthesized have strong antibacterial action against Gram-negative bacteria of Escherichia coli and Gram-positive bacteria of Bacillus subtilis, streptococcuspneumoniae, Staphylococcusaureus. Cissusquadrangularisextractantibacterialactivity, Titanium nanoparticles and zone inhibition values (mm) were compared and calculated.. In Bacillussubtilis (60 mm) the zone of inhibition is higher. Table.1.

Antibacterial activity of samples Ti-Ce:

Using the disc diffusion process, the antibacterial activity of Ti-Ce samples was determined. With Muller Hinton Agar, petridishes (60 mm diameter) were prepared with test species. At different concentrations of 20–100 μg/ml, sterile discs with a diameter of six millimetres were impregnated with 10 μl of crude methanolic extract. The prepared discs were placed on the top layer of the agar plates and left at room temperature for 30 min.Diffusion compound. Using the respective solvent, negative control was prepared. The dishes were incubated for 24 h at 37 °C and the zone of inhibition in millimetres was recorded, repeating the experiment twice [29,30].

3.9. In vitro anticancer activity of Ti-Ce nanoparticles

The in- vitro anticancer activity confirmed by the MTT assay on the MCF-7 cell lines showed IC50 extract values of 90.46 μg/mL and TiO_2 NPs values of 125.7 μg/mL.The killing potential of Ti-Ce NPs against breast cancer cells was 100, 97.05, 95.29, 93.82, 85.28, 76.66, 66.31, 56.52, 43.96, 35.62, 28.08 compared to TiO_2NPs (100, 94.66, 97.89, 96.34, 89.27, 28.08), which was substantially higher compared to that of plant extracts Fig. 12. [31] and at different concentrations, respectively, 1, 5, 10, 15, 50, 100, 200, 300, 400, 500 μg/ml of the extract compared to the control IC50 value of Ti-Ce NPs showed that the concentration needed to inhibit 55% of MCF-7 cells was lower than that of the TiO_2 NPs [30,31].

4. Conclusion

In this work, technically using in laboratory to bulky advantages in industries and biomedical applications. In conclusion, Cissusquadrangularis plant extract, and the TiO_2 NPs & Ti-Ce nanomaterial was successfully synthesized. The nanoparticles Ti and Ti-Ce were examined by XRD, FTIR, and SEM. The morphology analysis verified that Ce nanoparticles were decorated with TiO_2nanoparticles. Titanium's green synthesis nanoparticle observed Pb2+ ions and methylene blue dye degradation. Green synthesis of TiO_2 and Ti-Ce nanoparticles anti-microbial behaviour was exhibited in materials. The IC50 value of TiO_2NPs showed that the concentration needed to inhibit 55% of MCF-7 cells was lower than that of the extract of CissusQuadrangularis leaves.TiO_2 NPs—due to the high biocompatibility, tunable drug releasing ability and low toxicity—are recognized as an appropriate candidate to increase the clinical therapeutic effect of conventional chemotherapeutic agents through targeted delivery and controlled release. Biomedical applications of these nanomaterials can be categorized into biosensing, drug delivery, antibacterial activity and implant applications. Finally, in order to properly develop and use TiO_2 nanomaterials in medicine, further studies will undoubtedly be necessary (Figs. 5–7, 9–11 and 13, Table 2).

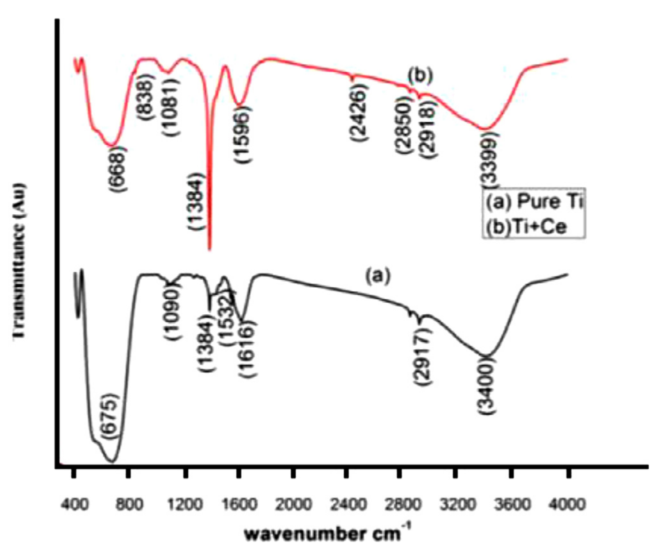

Fig. 5. FT-IR spectra (a) TiO_2 NPs (b) Ti-Ce NPs.

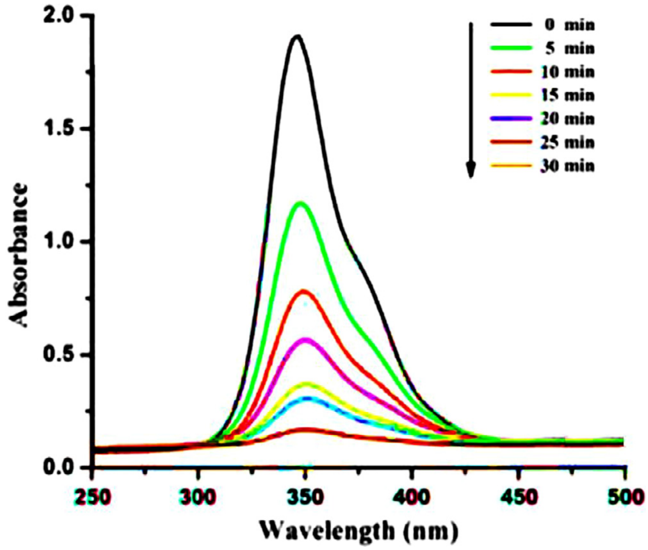

Fig. 6. The UV-Visible spectra of photocatalytic degradation of Methylene blue dye (a) 0 (b)5 (c) 10 (d) 15 (e) 20 (f) 25(g) 30 min.

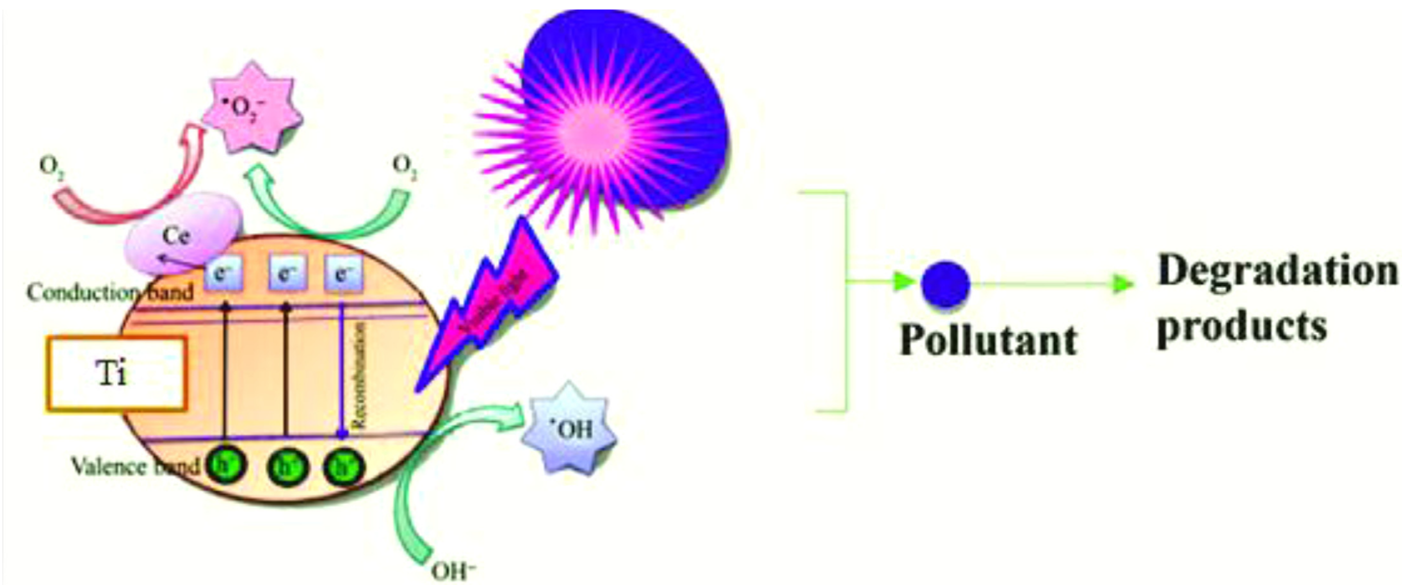

Fig. 7. The dye degradation processes of TiO_2 NPs.

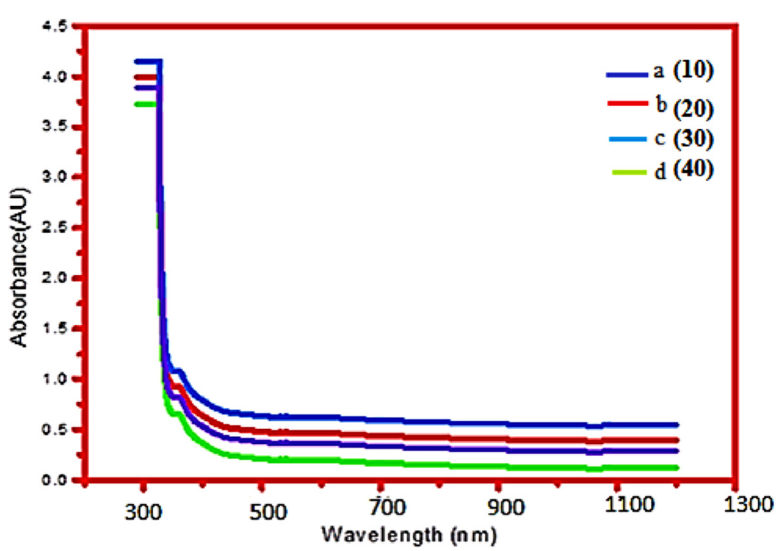

Fig. 8. (UV)–vis absorption spectra of TiO_2 NPs nanoparticles(after) the addition of Pb^{2+}(a)10 (b) 20 (c) 30 (d) 40 × 10^{-2} mol L^{-1}.

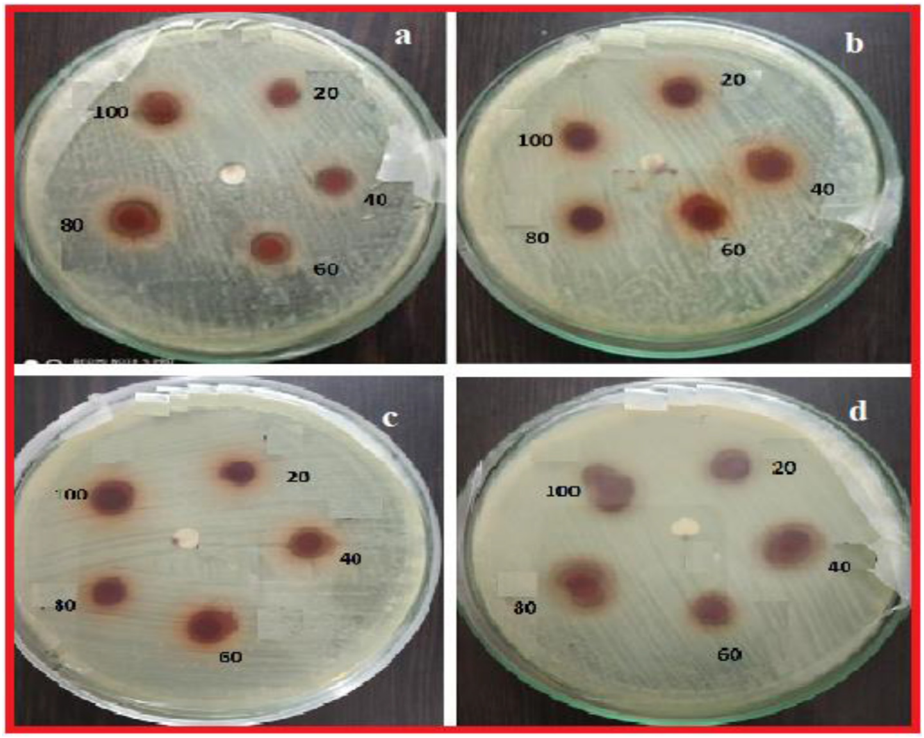

Fig. 9. Antibacterial activity of synthesized TiO_2NPs against (a).Staphylococcus aureus,(b) Bacillus subtilis, (c)Streptococus pneumoniae and (d) E. coli bacteria.

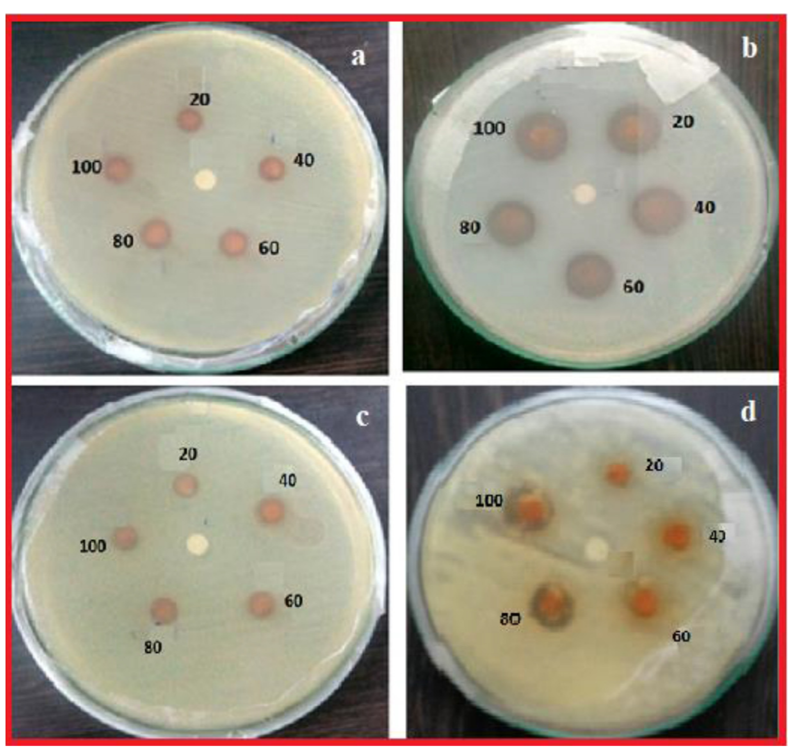

Fig. 10. Antimicrobial activity of synthesized Ti -CeNPs against (a). S. aureus, (b) Bacillus subtilis, (c) Streptococus pneumoniae and (d) E. coli bacteria.

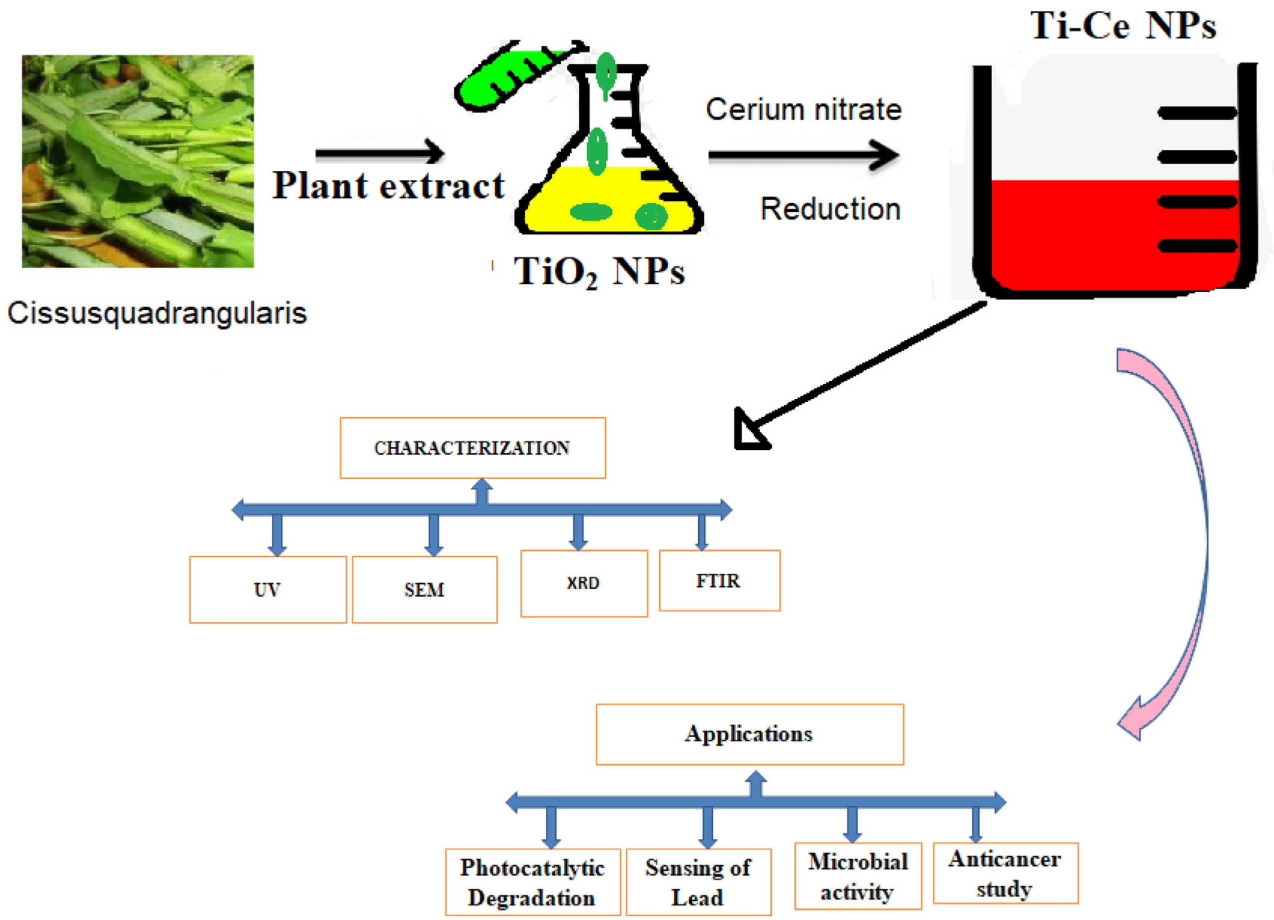

Fig. 11. Graphical abstract of synthesis of TiO_2 & Ti-Ce NPs.

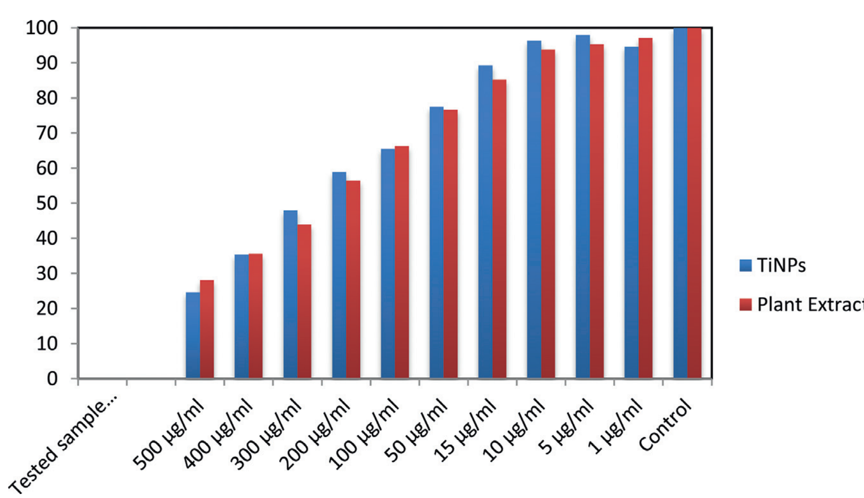

Fig. 12. Cell viability of MCF-7 cell line.

Table 2
Antibacterial activity of synthesized Ti-Ce NPs against (a). S. aureus, (b) Bacillus subtilis, (c) Streptococus pneumoniae and (d) E. coli bacteria.

Concentration	E. coli	Staphylococcus aureus	Streptococcus pneumonia	Bacillus subtilis
20	5 ± 0.2	0	4 ± 0.1	6 ± 0.3
40	6 ± 0.4	0	5 ± 0.1	7 ± 0.4
60	7 ± 0.2	0	6 ± 0.4	8 ± 0.4
80	8 ± 0.2	0	7 ± 0.4	9 ± 0.5
100	9 ± 0.2	0	8 ± 0.4	10± 0.5
10 µl/disc	0	0	0	0

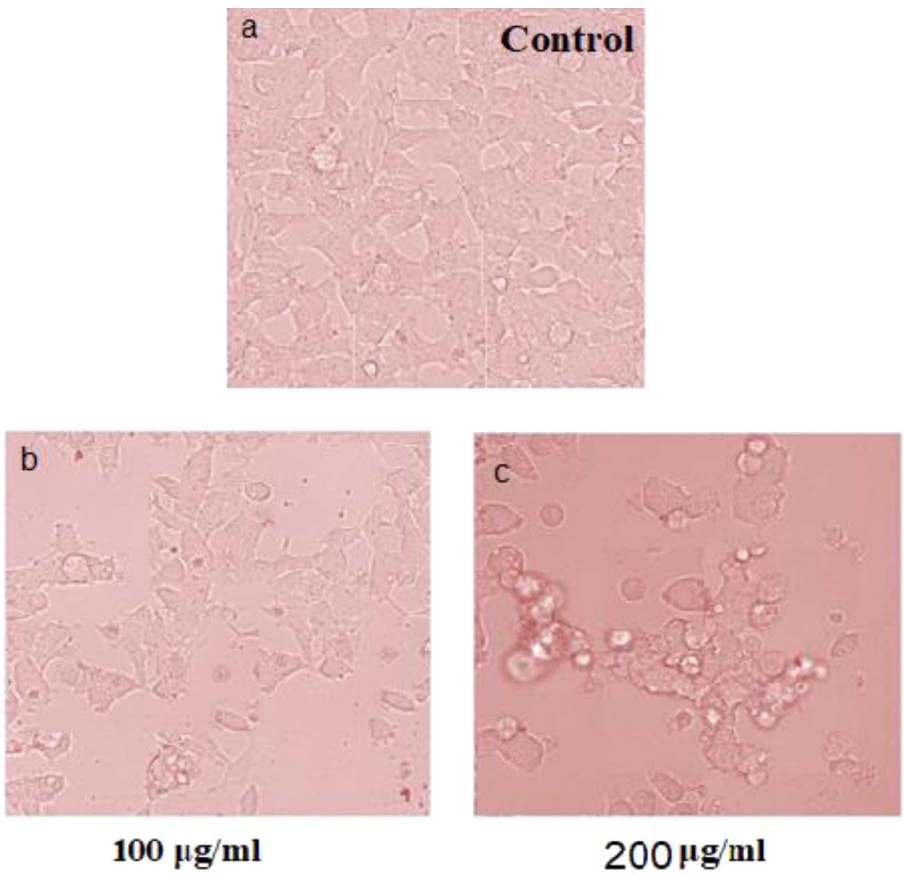

Fig. 13. Images of cell death at various concentration.

Authors' statement

C. Pragathiswaran: Corresponding Author, Author Conceptualization, Methodology, software writing-review and editing.

J. Violet Mary: Conceptualization, Methodology, software writing-review and editing

N. Anusuya: Data curation,Writing –original draft

The above three authors have contributed to make this article. The credit goes to all the three above authors.

Declaration of Competing Interest

I wish to submit an original research article entitled "Photocatalytic, degradation, sensing of Pb^{2+} using titanium nanoparticles synthesized via plant extract of Cissus quadrangularis: Invitro analysis of microbial and anti-cancer activities" for consideration of publishing an honour of editors Prof. Kaushik Pal and Prof. Sabu Thomas handling entitled special issue proposal on "Nanoarchitechtonics: From Molecules to Advanced Nanomaterials" through International Peer-reviewed Journal of Molecular Structure, Elsevier (Impact Factor: 2.463).reputed journal. I confirm that this work is original and has not published elsewhere. There is no conflict of interest, I believe that this manuscript is appropriate for publication by journal of Molecular structure.

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