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Developing Aluminum Nitride Nanoparticles: Chemical synthesis and Exploration of biocompatibility and anticancer activity against Cervical Cancer Cells

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AlN nanoparticles were synthesized using a simple and effective solvothermal method. The X-ray diffraction results revealed the cubic phase of AlN, and the field emission scanning electron microscopy analysis demonstrated the structural morphology of the synthesized materials. In addition, the cytotoxicity of the AlN nanoparticles was assessed against healthy (HEK-293, HUVEC, and MCF10A) and cancerous cell line (HeLa). The intensity of the reactive oxygen species was also measured to determine the induced oxidative stress in the treated cells. Ceramics have attracted the attention of researchers for their biological applications owing to their exceptional electronic, thermal, and optical properties, as well as their biocompatibility [1, 2]. Boron nitride and gallium nitride have been investigated as the potential candidates for biomedical use [3-5] Aluminium nitride (AlN) is a wide-bandgap semiconductor and nitride-based material. The wide applications of AlN are attributable to its high thermal conductivity with proper electrical insulation and high surface acoustic wave velocity. Furthermore, AlN possesses numerous other beneficial properties, such as hardness (up to 20 GPa), wide bandgap (~6.2 eV), high surface acoustic wave (SAW) velocity (depending on the crystal orientation) between 5760 and 10,500 m/s, electrical resistance (109 -1011 Ωm), high resistance to oxidation (>600 °C), high thermal conductivity (up to 320 W/mK), and low thermal expansion coefficient (4.2x10-6-5.3x10-6/K), which depends on crystal orientation [6-9]. AlN also has great resistance to various materials. AlN possesses unique properties that are considered efficient for biosensors and microelectromechanical devices. Implantable biomedical devices (e.g., smart sensors) have the potential to revolutionize the medical field. These devices should be able to communicate with an outside system via a wireless interface. AlN is considered to be a viable option for wireless and blue-tooth communications owing to its high SAW velocity AlN could be used for several biomedical applications, such as SAW sensors and implantable biomedical and microelectromechanical devices. However, the development of such materials is bound to one requirement, which is biocompatibility. The materials showing great chemical inertness, stability, and high compatibility with biological samples are considered optimal in this regard to be utilized in biomedical devices. The main benefit of the lower cytotoxicity is that the device could function properly without disturbing the functioning of the biological media unctioning of the biological media. In the present study, AlN nanoparticles were synthesized using a simple and effective solvothermal method, and the structural study was performed using X-ray diffraction (XRD). The biocompatibility of the synthesized AlN nanoparticles was evaluated against normal human HEK 293, HUVEC, and MCF 10A cell lines using the 3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyltetrazolium bromide (MTT) assay, and the anticancer potential of the nanoparticles was also assessed against cervical cancer cells. Additionally, the intensity of reactive oxygen species (ROS) was measured in order to determine the induced oxidative stress in the cell culture and cellular biocompatibility of the AlN nanoparticles The MTT assay was used for the screening of cell viability. The cytotoxicity of the AlN nanoparticles on the HeLa (cervical cancer), human embryonic kidney (HEK-293), human endothelial (HUVEC) and breast cell lines (MCF10A) was assessed. The cell lines were preserved in the Iscove's modified Dulbecco's medium. The medium was supplemented with penicillin (100 U/ml), GlutaMAX (2 mM), 10% fetal calf serum (FCS), and streptomycin (100 µg/ml), incubated at the temperature of 37°C in an atmosphere with 95% air and 5% CO2 , and maintained at 90% relative humidity. In brief, approximately 105 cells per well were incubated in 100 microliters of RPMI-1640 supplemented with 10% FCS, l-glutamine (2 mM), and various concentrations of the AlN nanoparticles (100, 200, 400, and 800 mg/l) for 24 hours.

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Four hours before termination, the supernatants were substituted with 10 microliters of the MTT solution (1 mg/ml) and 90 microliters of a fresh medium. After four hours of incubation at the temperature of 37°C, the medium was aspirated, and the formazan crystals were solubilized in 200 microliters of dimethyl sulfoxide. Optical density was obtained spectrophotometrically using Bio-Rad 840 at 570 nanometers. The relative cell viability (%) of the control cells (without AlN nanoparticles) was estimated based on the UV-Vis absorbance data obtained by the following formula: Cell Viability(%)=Atest/Acontrol x 100 (1)

In the formula above, [A]test and [A]control show the absorbance of the test and control samples, respectively. Following this method, the amount of cleaved MTT could be determined, which was proportional to the population of the viable cells. All the measurements were performed in triplicate.
CONCLUSION In this study, AlN nanoparticles were synthesized using a solvothermal method, precursor Aluminium powder, and ammonia solution at the temperature of 500ºC. The XRD analysis confirmed the formation of cubic-phase AlN nanoparticles, and the FE-SEM assessment demonstrated the spherical morphology of the synthesized samples. Moreover, cytotoxicity studies were used to analyze whether the nanoparticles could be used for biomedical applications. According to the cell viability results, the synthesized AlN nanoparticles were nontoxic to the healthy (HEK-293, HUVEC, and MCF10A) and cancerous cell lines (HeLa), causing no changes in cell morphology. These findings emphasized that AlN nanoparticles could be developed as a promising nontoxic material for further biomedical applications. Hereby, we extend our gratitude to the Department of Science and Technology in India for the financial support of this research project under the Science and Engineering Research Board (SERB) project number EMR/2016/002815. This study was also supported by UPE-II, UGC in New Delhi, India