Abstract

Research on nanomaterials (NMs) undertaken in recent years depicts a continuous demand to develop less toxic and safer NMs. The surface chemistry of commonly used NMs might be modified using various biomolecules or biocompatible materials. The present research was designed to develop and evaluate metallic nanoconjugates using different amino acids as capping materials.

Silver nanoconjugates (AgNCs), silver nanoprisms conjugates (AgNPrs), and gold nanoconjugates (AuNCs) were synthesized with different amino acids, such as L-cystine (Cys), L- tyrosine (Tyr), and L- glycine (Gly). Characterizations of the same were performed by using UV-visible spectroscopy, PSA, TEM, SEM, FTIR, zeta potential, etc. Prepared NMs were assessed for their *in vitro* antioxidant activity.

Tyrosine-AgNCs, Tyr-AgNPrs, Cys-AgNPrs, and Cys-AuNCs showed enhanced DPPH scavenging activity ($p < 0.05$). However, DPPH activity reduced in Gly-AgNCs ($p < 0.05$) and Gly-AuNCs ($p > 0.05$), whereas it was enhanced in Gly-AgNPrs ($p > 0.05$). The Cys-AgNCs, Gly-AuNCs, and Cys-AgNPrs displayed enhanced ferric reducing power activity. All conjugates of L-tyrosine, i.e., Tyr-AgNCs, Tyr-AuNCs, and Tyr-AgNPrs, showed good hydrogen peroxide scavenging activity than all other nanoconjugates.

Additionally, NMs also were assessed for their *in vivo* antioxidant potential against cadmium-intoxication in mice (*Mus musculus*). The LD-50 was calculated at 295.12mg/Kg of the bodyweight for chemically-synthesized silver nanoparticles (AgNPs). On exposure to silver NMs, minor deviations in endogenous enzymes and other parameters, histological and biochemical analyses revealed that the cystine- and tyrosine-capped AgNCs demonstrated enhanced *in vivo* results. The AgNPrs-exposed mice displayed a decreased ($p < 0.05$) catalase (CAT) activity in G2 and G3 and increased in G4, which was negligible in G5 and G6. The superoxide dismutase (SOD) activity was reduced in the G2 ($p < 0.05$) and G5 ($p > 0.05$) groups, whereas it increased in the G3 ($p < 0.05$), G4, and G6 groups of mice. The G2 showed a slightly decreased glutathione-s-transferase (GST) activity ($p > 0.05$), whereas G6 showed a negligible change. On exposure to gold NMs, CAT activity decreased in G2 group ($p < 0.05$) and increased in G3 ($p < 0.05$), G4 ($p > 0.05$), and G5 ($p > 0.05$) groups. The SOD activity increased in G3 ($p > 0.05$); however, it reduced non-significantly in G2, G4, G5, and

G6. Glutathione-s-transferase (GST) decreased ($p > 0.05$) in the G2, G3, and G4 groups of animals, while a minor change occurred in G5 and G6 groups. Reduced glutathione (GSH) and MTs in liver tissues of the cadmium (Cd)-exposed (G2) group elevated ($p < 0.05$). Histological analyses revealed that the tyrosine- and cystine capped NMs showed a protective role against cadmium toxicity.

Thiol (—SH) group-containing biomolecule, i.e., allicin, was extracted from the garlic cloves and used in the capping of AgNPs. Allicin-capped AgNPs displayed enhanced *in vitro* (DPPH assay) and *in vivo* antioxidant activity. Histological analyses and other findings revealed the antioxidant potential and safer biological nature of allicin-AgNPs.

Cystine-capped nanoconjugates reverted Cd-induced toxicity and oxidative stress in albino mice and showed a protective role. Among the chemically-synthesized NMs, only AuNPs showed intrinsic antioxidant activity, while AgNPs and AgNPrs exhibited pro-oxidant activity. It is concluded that these nanoconjugates can be effective in different biomedical applications. However, it needs detailed research and investigation to assess the safety profile of these NMs before using them for specific biomedical purposes.

Keywords: Nanotoxicity; Biogenic functionalization; Oxidative stress; Amino acids; metallic nanomaterials; Endogenous antioxidant enzymes; Metallothioneins (MTs), Safer nanoparticles.