Materials Advances

ROYAL SOCIETY OF CHEMISTRY

PAPER

View Article Online
View Journal | View Issue

Cite this: *Mater. Adv.*, 2020, **1**, 1142

Polyphenol capping on a gold nanosurface modulates human serum albumin fibrillation†

Aalok Basu,[ab] Sonia Kundu,[c] Aatrayee Das,[a] Chitra Basu,[d] Sagar Bhayye,[a] Suvadra Das[e] and Arup Mukherjee *[af]

Received 5th May 2020,
Accepted 11th June 2020

DOI: 10.1039/d0ma00274g

rsc.li/materials-advances

Different small molecules and nanomaterials have been known as inhibitors of protein misfolding and subsequent fibrillation, which marks the initiation of various degenerative conditions. This work explores the effect of polyphenol-capped gold nanoparticles on the extent of human serum albumin fibrillation. Silymarin-capped (SAuNPs), quercetin-capped (QAuNPs) and gallic acid-capped gold nanoparticles (GAuNPs) were synthesized with a uniform size range and their relative antioxidant capacity was determined through DPPH assay. The fibrillation of HSA at 65 °C was inhibited by ~15% in the presence of SAuNPs and the process was monitored through a combination of Thioflavin T fluorescence spectroscopy, circular dichroism spectroscopy and microscopic analysis. The inhibitory effect appeared much pronounced in the case of QAuNPs (~67%) and GAuNPs (~60%). Using SDS PAGE analysis, we demonstrated that the different inhibitory activity of SAuNPs, QAuNPs, and GAuNPs could be attributed to the antioxidant potential of the individual nanoparticles. Our work revealed that apart from protein–nanoparticle surface interactions, the antioxidant capacity has a role in determining the effectiveness of a protein fibrillation inhibitor. Cytotoxic analysis of protein–gold nanoparticle aggregates on HaCaT cell lines further confirmed that the nanoparticles were biosafe and can be considered as active therapeutics for translational use.

1. Introduction

Reactive oxygen species (ROS) are by-products of cellular metabolism and act as redox signalling molecules essential for the maintenance of physiological functions.[1,2] Excessive ROS produced are promptly scavenged by molecular chaperones as part of the proteostasis mechanism,[3] the failure of which can cause oxidative damage to the exquisitely arranged protein macromolecules. Under such conditions of oxidative stress, protein molecules, especially the newly synthesized ones, are susceptible to aberrant structural misfolding and subsequently experience molecular self-association to form amyloid fibrils. These fibrils are cytotoxic, and their deposition in tissues is often the pathogenic hallmark of certain degenerative conditions such as Parkinsonism, Alzheimer's disease, atherosclerosis, diabetes and several others.[4]

A considerable number of small molecules,[5] peptides,[6] surfactants,[7] quantum dots[8] and nanoparticles are capable of binding to amyloidogenic proteins and resisting the misfolding of their tertiary structures. Nanoparticles of *N*-isopropylacrylamide-*N*-butylacrylamide copolymer,[9] amino-acid based polymers,[10] gold,[11] graphene oxide,[12] and metallic oxides[13,14] have been explored as inhibitors of protein fibrillation, due to their tunable surface functionalities and high surface to volume ratio. Among them, gold nanoparticles (AuNPs) are of considerable interest in drug delivery, genetics, biosensing, and therapeutics due to their ease of synthesis with controlled dimensions, detection, facile bioconjugation, and high thermal stability.[15] AuNPs have also exhibited tremendous potency in the management of oxidatively stressed conditions through quenching of free radical species.[16,17] AuNPs have been strategically explored as one platform for studying the influence of nanosurface charge,[18] surface chirality,[19] shape and size[20] on protein fibrillation.

[a] *Department of Chemical Technology, University of Calcutta, 92 A.P.C. Road, Kolkata 700009, West Bengal, India. E-mail: arupm1234@gmail.com; Fax: +91 33 23519755; Tel: +91 33 23508387*
[b] *Dr B.C. Roy College of Pharmacy and Allied Health Sciences, Bidhannagar, Durgapur 713206, West Bengal, India*
[c] *Department of Pharmaceutical Science and Technology, Maulana Abul Kalam Azad University of Technology, BF 142, Sector 1, Salt Lake City, Kolkata 700064, West Bengal, India*
[d] *Department of Biophysics, University of Calcutta, 92 A.P.C. Road, Kolkata 700009, West Bengal, India*
[e] *Basic Science and Humanities Department, University of Engineering and Management, University Area, Plot, Street Number 03, Action Area III, B/5, Newtown, Kolkata 700156, West Bengal, India*
[f] *Department of Biotechnology, Maulana Abul Kalam Azad University of Technology, BF 142, Sector 1, Salt Lake City, Kolkata 700064, West Bengal, India*

† Electronic supplementary information (ESI) available. See DOI: 10.1039/d0ma00274g