Nanoparticles may influence biochemical pathways

Nanoparticles are increasingly used in a wide range of applications in science, technology and medicine. Several studies specifically dealing with the toxicity of nanoparticles have appeared recently, showing the influence of nanoparticles on numerous biochemical pathways in living systems. Also studies project these adverse health effects of nanoparticles as a part of ambient air pollution[1].

Researchers at Dublin's School of Medicine, Ireland have studied the exposure of human cells to a wide range of nanoparticles with different physical and chemical properties. Human cells derived from the lining of airway passages were exposed to nanomaterials, including ultrafine carbon black, carbon nanotubes and silicon dioxide particles of different sizes. Lungs of mice were exposed to single-walled carbon nanotubes (SWCNTs). The study demonstrated that nanomaterials of distinct origin, morphology and physico-chemical properties were able to induce protein citrullination via increased Ca^{2+}-mediated PAD activity and results showed that exposure to nanoparticles facilitated post-translational citrullination of proteins, a post-translational modification process which modifies the amino acid arginine to a molecule called citrulline, by enzymes called peptidyl arginine deiminases (PADs). Unlike arginine, citrulline being uncharged has important consequences in the structure and function of a protein. Several proteins like cytokeratinis 7, 8 and 18, and plectins were identified as targets for citrullination. The change in immune response developing as a result of human exposure to nanoparticles through the citrullination-dependent mechanism could facilitate autoimmune diseases[1].

Serious concern has been raised related to the potential toxic effects in the respiratory system upon inhalation of SWCNTs. A recent study examined possible SWCNTs-induced toxic mechanisms *in vivo* in mice. The results indicated that a single intratracheal instillation of SWCNTs could induce airway hyper reactivity and airflow obstruction. The lung pathology and even airway alterations in the mouse model were found to be similar to the obstructive airway disease in humans[2].

In the recent past, a team of scientists from Cornell University, USA studied how nanoparticles found in substances from food additives affected the absorption of an essential nutrient, iron, into the cells of chicken. The researchers used commercially available, 50 nm polystyrene carboxylated particles that are generally considered safe for human consumption. Chickens acutely exposed to carboxylated particles had a lower iron absorption than unexposed or chronically exposed birds. The chronic exposure has caused the surface area available for iron absorption to be increased due to remodelling of the intestinal villi. According to the study, nanoparticle size, concentration and charge can influence iron uptake and iron transport at doses that represent a potential human exposure[3].

In the coming years, the extensive demand for nano-engineered products may lead to the strong possibility of an increasing variety of nanomaterials being introduced into everyday life. Carefully designed toxicity studies may be needed to ensure the extended safety of nanomaterials products.

1. Mohamed, B. M. *et al*., *Nanomedicine*, 2012; DOI: 10.2217/nnm.11.177.
2. Hsieh, W. Y. *et al*., *Am. J. Respir. Cell Mol. Biol.*, 2012, **46**, 257–267. Epub 2011 Sep 29. PubMed PMID: 21960547.
3. Mahler, G. J. *et al*., *Nature Nanotechnol.*, 2012, **7**, 264–271.

Hardik Panchal

Drag time or drop it: debate of a leap second

During the last century, solar time was adopted as a universal standard time by an international consensus in 1884. Officially, the solar time of the Greenwich meridian was named as Universal Time, which is now termed as Greenwich Meridian Time (GMT).

More recently, the precision of atomic clocks has influenced the process of calculating and reckoning time. In the 1950s atomic resonators were introduced and the atomic second entered into the precise calculation of time. In the next decade, radio broadcasts started depending on atomic chronographs (graphs used for calculating the atomic oscillating time). From 1972, time-checkers defined Coordinated Universal Time (UTC) which is considered as the successor of GMT. UTC uses atomic seconds and the insertion of occasional full-second leaps as it tracks the mean solar time. A term called International Atomic Time (TAI) was introduced which is a combination based on the several highly precise atomic clocks. UTC is basically used to determine local times in the time zones worldwide[1].

In the world of atomic clocks, while calculating a day which has 86,400 sec, a second here is the time taken by a cesium-133 atom in the ground state oscillating precisely 9,192,631,700 times. Similarly, the insertion of leap seconds is due to the fact that the present length of the mean solar day is about 2.5 ms (0.002 sec on an average) longer than a day of precisely 86,400 SI sec. So over the entire year, a considerable difference of a second comes between the normal earth daytime and UTC[2,3].

The interesting fact to note here is that before the difference exceeds 0.9 sec, a second as an integral number is added to UTC. The extra second is known as 'leap second'. The decision regarding the insertion of each UTC leap second is taken approximately six months in advance by the International Earth Rotation and Reference Systems Service (IERS)[3]. These adjustments began in 1972; before this time was measured exclusively as expressed in GMT or UT1. Between 1972 and 2012, 25 leap seconds were scheduled and all were inserted successfully. The last leap second scheduled was added recently on 30 June 2012.

Starting with the UTC questionnaire distributed by IERS in 1999, many international scientific organizations are engaged in a discussion to modify the definition of UTC. In particular, it has been proposed to remove leap seconds from the international reference time (UTC)[4]. Time-keepers from all over the world are engaged in a protracted debate on the decision to continue the addition of a leap second.

Experts agrue that if precise technology has kept time in sync with nature, a leap second should not be dropped as it might result in major changes in universal time with respect to the mean solar time. The removal of a leap second might have consequences when the accumulated difference between earth rotation time and atomic clocks reaches a precise level, i.e. 2–3 min in 2100 and about 30 min in 2700 (ref. 5).

However, some technical experts believe that every time a leap second is introduced, it might cause serious difficulties in telecommunication and synchronized computer systems. Telecommunication systems which rely on precise time synchronization could lead to loss of communication until time synchronization is re-established. Additionally, computers are only programmed to take up seconds up to digits ‘59’ and introduction of value ‘60’ may cause the systems to crash[3,6].

In future, the scientific timekeeping communities of the world have to decide on the proposal to remove the leap second. The world’s timekeepers will vote in 2015 on a proposal after postponing the decision in January 2012 at a Radiocommunication Assembly of International Telecommunication Union.

1. Finkleman, D. *et al.*, *Am. Sci.*, 2011, **99**, 312–319; DOI: 10.1511/2011.91.1.
2. Nelson, R. A. *et al.*, *Metrologia*, 2001, **38**, 509.
3. McCarthy, D. D. *et al.*, *Astron. J.*, 2008, **136**, 1906.
4. Finkleman, D., Seago, J. H. and Seidelmann, P. K., AIAA Paper; 2010–8391, American Institute of Aeronautics and Astronautics, Inc, USA, 2010.
5. International Telecommunication Union, Press release, 19 January 2012.
6. Kamp, P.-H., *Commun. ACM*, 2011, **54**, 44–48.

Hardik Panchal (*Science Writing Intern*)
e-mail: hardikpanc87@gmail.com