Conclusion, Introduction, Drug Delivery, Solubility, Nanofibers, Toxicity

Medicine has thrived through the incorporation of nanotechnology in its discipline as the efficacy of drugs improved significantly due to its implementation in drug delivery, isolation of cancer cells in the body and reparations in clogged arteries. However, use of nanotechnology can be risky, as particles behave differently at a nanoscale level. This unpredictability can pose hazards to human health if it is unable to be controlled in its application in medicine. Substances such as engineered fibrous nano-materials can cause inflammation on lungs while the small size of individual particles allows them to enter cells and form clumps. This report will explore the risks and hazards which nanotechnology carries in its application in medicine on human health.

Nanoparticles hold great significance in the field of medicine due to their frequent emergence: they are everywhere from wound dressings to drug delivery. However, much of the disadvantages in its application is yet to be researched, as whatever little information is available, it only comes from inhaled nanoparticles. If not researched thoroughly, the risk of nanoparticles could increase significantly, as it has already been demonstrated in lab rats which resulted in lung inflammation and blood clotting. Furthermore, the high surface area of nanoparticles makes them particularly sensitive when it comes to reactivity, which inside the human body could trigger unwanted reactions, in turn causing damage to cells and organs. Therefore, the subject of nanoparticles should be treated with caution, especially when it comes to application on humans in order to allow for safer usage in medicine.

Nanofibre membranes from bipolymers are used as drug carriers or bioactive compounds. The benefit of this is that the membranes are engineered to specifically target diseased cells, therefore reducing the damage done to healthy cells. The benefits of using nanoparticles in drug delivery is that it is possible to attach ethylene glycol molecules, which enables the nanoparticles to circulate in the blood stream. It is ethylene glycol molecules which stop the white blood cells from attacking the nanoparticles. While the benefits of nanoparticles in drug delivery are immense, there are serious adverse effects which need to be researched further: cationic nanoparticles, which are ligand coated nanoparticles used as agents for drug delivery, such as gold and polystyrene have been shown to cause haemolysis (rupture of red blood cells) and blood clotting (De Jong and Borm, 2008). Positive correlation is also observed between nanoparticle exposure and the amount of cardiovascular diseases; however, there is no definitive explanation. Toxicological studies have demonstrated that certain nanoparticles can gain access to the blood following inhalation and can enhance experimental thrombosis (blood clotting in circulatory system) but it is not clear whether this was an effect of pulmonary inflammation or particles translocated to the blood. Another type of nanoparticle, DEP (Diesel exhaust particulate), was shown to cause altered heart rate in hypertensive rats, whereas high concentrations of anionic nanoparticles and cationic nanoparticles were toxic for the BBB (blood and brain barrier) (De Jong and Borm, 2008).

Different types of nanoparticles have varying solubility, and it is those nanoparticles with low solubility that could pose the most health risks. The risks are greater if the nanoparticles comprise inorganic metal oxides and metal, as they could react with bio-molecular structures within the body. Another factor to consider is if they are able to be broken down and be degraded: it would lead to the nanoparticles to accumulate within the body and damage organs. Furthermore, due to its high reactivity and electrical charge, nanoparticles create conditions within the body where they come together to form larger particles, described as "particle aggregation". This could potentiate the risks even further as this alters their physiochemical properties leading to unknown reactions inside cells.

Nanofibers are fibres that have diameters of less than 1000 nm, and their medical applications range from wound dressings to artificial organ transplants. Nanofibers are created by an electrospinning process that ranges from 10 nm to several hundred nanometres. The unique process through which it is made gives the nanofibers special properties due to its high surface area to mass ratio, such as low density, high pore volume, and tight pore size. Researchers have also demonstrated new ways to make nanofibers out of proteins naturally occurring in blood, which makes it ideal for use in bandages as they eventually dissolve in the body (Hegde, Dahiya, and Kamath, 2005). This also makes it possible to add antibacterial material and drugs to the nanofiber structure, minimising infection rate, blood loss, and making it more effective as it is absorbed by the body. Another field within medicine where nanofibers are used is tissue engineering, making them possible substrates for growing cells. Nanofiber substrates effectively support cell multiplication and enable tissue replacement prepared from a patient's cells. The material it is made from also makes it possible to incorporate different bioactive materials and drugs. Barrier textiles, when containing hydrophobic nanofibre layers, work as effective barriers for microorganism penetration, such as viruses and bacteria (Nanofiber applications, 2004). However, nanofibres can also pose significant health risks to humans. When silver nanofibres of different lengths were injected into lungs of mice, those larger than 5000 nm in size became lodged in lungs and caused inflammation while the smaller ones cleared away (BBC, 2012). Still, it is questionable whether the same results are applicable to humans, as the test was done on mice.

The toxicity of the nanoparticles is also dependent on its size, as particles at the nanoscale level lead to an increase in surface area to mass ratio. This means more chemical molecules are present on the surface of the nanoparticles, which enhances toxicity. During the study of low toxicity particles, TiO_2 particles with higher surface area were shown to induce more severe lung inflammation and particle lymph node burden compared to $BaSO_4$ particles with lower surface area (Tran et al 2000). Furthermore, their large surface area makes them highly reactive, which could lead to activate unknown chemical reactions or to bond with toxins, allowing for nanoparticles to enter cells other than the ones targeted.

Shapes also play a key role in the characteristics such as the respirability and inflammatory potential of individual nanoparticles. A prime example of these are nanotubes. In addition to being carcinogenic, single - wall carbon nanotubes where shown to induce Lung Granulomas, a type of inflammation, and thus demonstrated to be very toxic. However, this could also be due to the high mass dose. To add, studies using human keratinocyte cell line also showed that carbon nanotube exposure resulted in cell toxicity and accelerated oxidative stress (Shvedova et al 2003), which is an imbalance between the free radical production in the human body and the ability to neutralise its harmful effects.

Nanotechnology is a branch of technology which involves manipulating with structures and properties at the nanoscale range, from 1 to 100 nanometres. A particle which is 1 nanometre in size is 1×10^{-9} metres small - a billionth of a metre. With the concept introduced initially in 1959 by physicist Richard P. Feynman during his "There's Plenty of Room at the Bottom" talk, where he expressed the ability to control and manipulate individual atoms and molecules, the study has today developed exponentially to revolutionise perspectives in cosmetics industry, agriculture and most recently, medicine.

One of the major characteristics of nanoparticles is its toxicity and so far most of the research done around this area comes from inhaled nanoparticles in the air. What makes nanoparticles toxic in particular is their individual chemical properties, with Carbon Black nanoparticles causing more severe health effects compared to its other counterparts. However, it is subjective to contamination caused by human activity, such as pollution, as well as the fact that nanoparticles in the ambient air have complex composition, with organic and metal components such as metallic iron interacting, which may cause the adverse health effects. Metallic iron was shown to potentiate the effect of Carbon Black nanoparticles through increased reactivity (Wilson et al 2002).

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