Sub-statement on the potential risk(s) from exposure to microplastics: Inhalation route

Microplastics - Inhalation route - Toxicokinetics

In this guide

In this guide

55. As discussed in COT Statement Number 2021/02 , the toxicity of microplastics is dependent on a number of factors including size, morphology, chemical composition, additive leaching and surface functionalization.

56. Surface functional groups may affect the adsorption of organic contaminants and heavy metals leading to differences in their mobility and toxicity (Kim et al., 2017; Sun et al., 2020; Yao et al., 2022). However, the MP vector effect is usually framed as ‘complex’, ‘under debate’ or ‘controversial’ (Koelmans et al., 2022b).

57. Deposition of respirable fibres occurs in the lung as a function of the aerodynamic diameter of the particle, whereas non-respirable fibres are often inhaled through the nasal passage but are then caught in mucus and swallowed

thus creating a secondary exposure via the gastrointestinal tract. There are four main mechanisms of deposition in the lung: impaction, sedimentation, diffusion, and interception (Darquenne, 2006).

58. Inertial impaction occurs for particles with a diameter > 5 µm or for those with excessive momentum. As a particle travels through the airways, it remains on the same trajectory. If the air flow changes direction, the particle will remain on its existing pathway, deviating from the changed airflow and impacting on to the surface of the airways. Inertial impaction occurs in the upper respiratory tract and the conducting zone only.

59. For particles with a diameter between 0.5 to 5 µm, the main deposition mechanism is sedimentation. This occurs mainly in the bronchi and bronchioles; when air resistance and gravity overcome the buoyancy of the particle causing it to settle on the surface of the lung.

60. Airborne particles are in constant random Brownian motion, due to collisions with gas molecules. This results in random, omnidirectional particle movement, known as diffusion. This occurs only with smaller particles, typically < 0.5 µm. Occasionally particles will collide with the cell surface, causing them to settle there. Diffusion occurs mainly in the small airways and alveoli, although the particles can also deposit in the upper airways by this mechanism particularly when their diameter is < 0.01 µm (Tsuda et al., 2013).

61. Interception occurs when fibres with a large ratio between their length and diameter travel so close to the surface of the lung that they make contact. Deposition by interception increases with the length of the fibre. The area of deposition in the lung is dependent on the aspect ratio of the fibre but can also arise due to changes in airflow.

62. The deposition of inhaled microplastics in the lung is dependent on the particle’s physicochemical properties, as well as the subject’s physiology and lung anatomy. Deposition in the upper airways occurs by impaction, while in the small airways it occurs by sedimentation. Fibres have higher potential than spherical particles for penetration due to their high aspect ratio (Donaldson & Tran, 2002). Clearance relies on mechanical processes (e.g. mucociliary clearance where the mucous progresses towards the pharynx caused by the beating of cilia), alveolar macrophage phagocytosis and migration, and by lymphatic transport, which can result in secondary deposition in the GIT.

63. Clearance mechanisms for inhaled MPs > 5 µm, are likely to occur via the mucociliary escalator. Sneezing clears larger particles trapped in the nose/upper respiratory tract. Mucociliary transport clears particles from bronchioles/lower respiratory tract, with swallowing and GIT exposure. Coughing plays a role in both of these mechanisms.

64. Some particles bypass the mucociliary clearance and travel deeper into the lung where phagocytosis occurs. Macrophages may break down particles < 20 µm by either dissolution or degradation but this is dependent on the particle composition. If a particle is > 20 µm in length, macrophages will not be able to fully engulf the particle, resulting in frustrated phagocytosis (Donaldson et al., 2010). This state causes an increased recruitment of macrophages, which can result in the phenomenon known as an “oxidative burst” occurring where inflammatory mediators and oxidants are released in high concentration, potentially leading towards the onset of lung inflammation and fibrosis (Donaldson et al., 2010; Gasperi et al., 2018). Inflammation can induce cell proliferation and secondary genotoxicity due to the continuous formation of reactive oxygen species (ROS), resulting in oxidative stress, but this depends on a number of factors.

65. It is believed that once particles reach the pleura then they may reach the pleural space, however it is currently unknown how this particle migration occurs. Once particles reach the pleura, they may then travel to the lymphatic system which also helps clear phagocytic cells (Donaldson, et al., 2010; Enyoh et al., 2019). Possible translocation across alveolar walls into blood vessels with secondary translocation into tissues and organs may then occur (Fournier et al., 2020; Wright and Kelly, 2017).