Multilayer nanofibre face mask helps to combat pollution

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The multilayer nanofibre filter can provide high protection with low pressure drop, allowing users to breathe comfortably. Credit: The Hong Kong Polytechnic University

Researchers at the Hong Kong Polytechnic University have developed a ground-breaking filter technology that guards against the finest pollutants in the air.

Haze is usually composed of pollutants in the form of tiny suspended particles or fine mists/droplets emitted from vehicles, coal-burning power plants and factories. Continued exposure increases the risk of developing respiratory problems, heart diseases and lung cancer. Can we avoid the unhealthy air?

A simple face mask that can block out suspended particles has been developed by scientists from the Department of Mechanical Engineering at the Hong Kong Polytechnic University (PolyU). The project is led by

Professor Wallace Woon-Fong Leung, a renowned filtration expert, who has spent his career understanding these invisible killers.

In Hong Kong, suspended particles PM 10 and PM 2.5 are being monitored. PM 10 refers to particles that are 10 microns (or micrometres) in size or smaller, whereas PM 2.5 measures 2.5 microns or smaller. At the forefront of combating air pollution, Professor Leung targets ultra-fine pollutants that have yet been picked up by air quality monitors – particles measuring 1 micron or below, which he perceived to be a more important threat to human health.

"In my view, nano-aerosols (colloid of fine solid particles or liquid droplets of sub-micron to nano-sizes), such as diesel emissions, are the most lethal for three reasons. First, they are in their abundance by number suspended in the air. Second, they are too small to be filtered out using current technologies. Third, they can pass easily through our lungs and work their way into our respiratory systems, and subsequently our vascular, nervous and lymphatic systems, doing the worst kind of harm."

Professor Wallace Woon-Fong Leung, a renowned filtration expert, and his team from the Department of Mechanical Engineering at PolyU have successfully developed a simple face mask which can block out suspended particles. Credit: The Hong Kong Polytechnic University

However, it would be difficult to breathe through the mask if it were required to block out nano-aerosols. To make an effective filter that is highly breathable, a new filter that provides high filtration efficiency yet low air resistance (or low pressure drop) is required.

According to Professor Leung, pollutant particles get into our body in two ways – by the airflow carrying them and by the diffusion motion of these tiny particles. As the particles are intercepted by the fibres of the mask, they are filtered out before reaching our lungs.

Fibres from natural or synthetic materials can be made into nanofibres around 1/500 of the diameter of a hair (about 0.1 mm) through nanotechnologies. While nanofibres increase the surface area for nano-aerosol interception, they also incur larger air resistance. Professor Leung's new innovation aims to divide optimal amount of nanofibres into multiple layers separated by a permeable space, allowing plenty of room for air to pass through.

A conventional face mask can only block out about 25% of 0.3-micron nano-aerosols under standard test conditions. Professor Leung said: "The multi-layer nanofibre mask can block out at least 80% of suspended nano-aerosols, even the ones smaller than 0.3 micron. In the meantime, the wearer can breathe as comfortably as wearing a conventional face mask, making it superb for any outdoor occasions. Another option is to provide a nanofiber mask that has the same capture efficiency as conventional face mask, yet it is at least several times more breathable, which would be suitable for the working group."

The new filtration technology has been well recognized. Recently, Professor Leung and his team won a Gold Medal and a Special Merit Award from the Romania Ministry of National Education at the 42nd International Exhibition of Inventions of Geneva held in Switzerland.

If the breakthrough is turned into tightly-fit surgical masks, they are just as effective against bacteria and viruses whose sizes are under 1 micron. "In the future, medical professionals at the frontline can have stronger protection against deadly bacteria and viruses," added Professor Leung.

In addition, a new gas purifying technology is under development to convert harmful pollutant gases, such as NOx and volatile organic compound, to harmless substances including acids, carbon dioxide and water vapour.

Going beyond personal protection, the filtration and purifying technologies when combined can also clean the air in buildings and improve indoor air quality. Professor Leung said they could make air-purifying filters that are easily fitted into old and new buildings, without any extra supporting structures or additional costs. Therefore, the potential is limitless; air-purifying filters can also be installed in the cabins of airplanes, vehicles, trains and ships. Such a handy solution can be the way of future for "cleaner and healthier" air.

Provided by Hong Kong Polytechnic University