Forecast for accidents with nanomaterials

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Researchers have for the first time estimated how probable the accidental release of nanomaterials will be in the future. They based this on models from the nuclear industry. For a risk assessment, the results now have to be linked to information about the hazardous nature of the materials.

Every year, more than two million tonnes of nanomaterials are produced and used for a wide variety of consumer goods. Concerns have been repeatedly raised over the past two decades that these chemicals, with particles as small as 1 to 100 nanometres (millionths of a millimetre), could have harmful effects on humans and the environment. Many studies have investigated the risks associated with the use of artificial nanomaterials, but no project has yet looked at the unintentional release of these substances in the event of an accident in the production factory or during transport.

“For the first time, we have estimated the probability that accidents involving artificial nanomaterials will occur somewhere in the world in the next ten to thirty years,” says Ralf Kägi, head of the particle laboratory at the aquatic research institute Eawag. The study was coordinated by the UK Natural Environment Research Council (NERC) as part of an EU project and was largely carried out by the Swiss company ETSS as well as Eawag. The researchers have now published their results in the journal Nature Nanotechnology. They conclude that minor accidents with a limited release of nanomaterials in the range of a few kilograms will occur relatively frequently over the next ten years; the researchers expect two or three such events per year. Serious accidents, in which ten to a hundred thousand times more material is released into the environment, are much less frequent, according to their estimates. The probability that there will be at least one such accident in the next ten years is about seven percent, and in the next thirty years it will be ten to twenty percent.

Complex data situation

“The principles of our models are based on calculations that are also used for the nuclear industry,” says Fadri Gottschalk from ETSS. In the case of nuclear power plants, there is a comprehensive methodology for compiling probabilistic risk analyses. “However, the data situation for nanomaterials is much more complex than for nuclear power plants,” says the expert. While the nuclear industry focuses, for example, on a limited range of possible events that could trigger an accident, with nanomaterials there is no way of knowing where something could go wrong. The authors of the study therefore did not make any technical considerations about the causes of accidents, but projected the unintentional release of artificial nanomaterials from the past into the future.

The French database ARIA, in which chemical accidents are documented worldwide, served as the basis. “Unfortunately, they do not report whether nanomaterials were involved,” says Kägi. In order to reconstruct how many accidents with nanomaterials there actually were in the past, the researchers used two different methods. In a preliminary model, it was assumed that the share of released artificial nanomaterials would correspond to the market share of these substances, which is currently 0.5 percent of the total chemicals market. They therefore assumed that on average 0.5 percent of the accidents in the ARIA database involved the release of artificial nanomaterials. This data, in combination with the computer models developed, enabled the research team to estimate the probability of future nano-accidents.

Dust explosion in a processing plant

In a second model, Kägi selected a thousand chemical accidents from the ARIA database and analysed them in more detail. He suspected a release of nanomaterials in twelve events. For example, a dust explosion occurred in a plant for processing zirconium and titanium scrap. The cloud of burning particles spread to open zirconium and titanium canisters and caused a second explosion and fire. Zirconium and titanium nanoparticles were very probably released into the surroundings. In another accident, a fire broke out in a filtration plant at a metal powder factory. Cobalt and magnesium nanoparticles were very probably released in the process.

The Eawag researcher submitted the accident reports to a panel of eleven chemical experts, who classified the incidents according to the probability of a release of nanomaterials. From this, ETSS also calculated forecasts for accident frequency over the next ten to thirty years, independently of the first model. The results of both model calculations were in good agreement. “Therefore, we are confident that we have made realistic predictions about future nanomaterial accidents,” says Kägi, “although we were faced with enormous uncertainties.”

Basis for insurance companies

The main benefit of the study was that it was now possible to quantify the uncertainties, says the researcher. “Insurance companies now no longer have to rely on their intuition to predict such accidents, but can use these figures to calculate and develop scenarios.” The next step is to link the probability estimates with information on the hazardous nature of the released materials to create risk analyses. Only then can the hazard potential for individuals and society be quantified.

Currently, it is mainly silicon dioxide and titanium dioxide that are produced as nanomaterials on a large scale – substances that are classified as harmless. Compared to this, the production quantities of exotic, more toxic materials are very small. Moreover, Kägi is convinced that the effects of future accidents with nanomaterials will not extend over hundreds or thousands of kilometres as in a nuclear disaster. “It will most likely be a local problem, where primarily the surrounding population will have to be protected.”

Cover picture: While the risks from the use of artificial nanomaterials have been well studied, no project has yet addressed the unintended release of these substances in the event of an accident in the production factory or during transport. (Photo: istock)

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