ObservatoryNANO

BRIEFING No.24

TEXTILES

SEVENTH FRAMEWORK PROGRAMME

Nano-enabled automotive textiles

The automotive industry is potentially a major beneficiary of nanotechnology developments which promise improvements and benefits at various levels providing lighter, stronger, harder materials, improved engine efficiency, reduced fuel consumption, reduced environmental impact, improved safety, and comfort. People spend ever more time in their cars and therefore safety and comfort become increasingly important. Textile materials have an important role here, for their use spans from interior panels for doors and pillars, seats coverings and paddings, parts of the dashboard, to cabin roof and boot carpets, headliner, safety belts, airbags, air filtration, tyre cord, and trimmings. Moreover, the use of textiles, in particular natural-based materials thanks to their easier recyclability, contributes to reducing car weight by replacing many conventional hard-surface structures. The share of textiles in a mid-range car weight is currently around 25 kg, and is expected to rise to 35 kg by 2020, with a contribution to an overall weight reduction of up to 30 kg[1, 13]. Traditional fabrics used for automotive interiors face several major challenges such as protection from dust and dirt, ventilation, durability and wear, and fire resistance; all of which call for new high-tech textiles providing enhanced and/or new functionalities. Nano-enabled developments may offer novel solutions and address multiple functionality requirements.

Nanotechnologies add value

Nonwovens and felts represent some 50-60% of the increase of textiles in a car; nano fibres can be used to produce those materials contributing very effectively both to weight reduction, noise absorption and insulation. But nanotechnology-related textiles can have a much wider reach. An important goal of the car industry's commercial strategies today is to enhance both the intrinsic and the perceived quality and comfort in a vehicle and textiles have a major role to play.

The principal features required to make a car interior safe, good looking, and comfortable include:

- Good management of heat and water vapour transfer;
- Anti-stain/easy to clean characteristics;
- Antimicrobial/antibacterial properties;
- Anti-allergic trimming;
- Flame resistance;
- Antistatic properties; and
- Improved acoustic performance.

Nano-enabled textiles may offer potential solutions to a number of these demands:

Moisture wicking - Textiles with moisture wicking and transpiration absorbing features are particularly valuable for comfortable driving. Successful results have been obtained by coating textiles with a hydrophilic coating of TiO2 nanoparticles or by plasma treatments to non-woven fabric which provide the desired surface functionality. This application is not yet utilised within the automotive textile industry though it is likely in the research phases.

Self cleaning/dirt repellent - New nano-finishing techniques, using nanomaterials, like fluorocarbon nanopolymers[2] bonded onto the fabric surface by wet or dry processes (plasma treatment), help keep fabrics clean by avoiding dirt, water and oil sticking to the fabric. The use of dry processes has the added benefit of being less energy intensive and more environmentally friendly than wet processes. While non-nano options are available, they do not currently provide textiles with the same flexibility and comfort that nano-coatings offer. Nano-enabled textiles are beginning to enter the market; with Insignia (Car of the Year 2009) Opel is the first manufacturer in the world to equip a seating upholstery with the nano-enabled Nanogate coating that prevents dirt and liquid staining[3].

Air purification/filtration - The quality of the air inside the car is paramount for the comfort and

Box 1: SELF CLEANING TEXTILES

Nanotechnology allows for dirt-repellent (self-cleaning) textiles. Nanoparticles give the surface of textile fibres a structure with an effect similar to that of the lotus plant's leaves, making water and dirt just roll off. Tiny particles measuring less than 100 nm on the textile fibres produce a similar self-cleaning effect. These surfaces are coated with billions of nanoparticles so close together that a speck of dust would not fit between them. Between a particle of dirt and the surface of the textile fibres, a layer of air is formed on which the impurities slide and can be washed off with water.

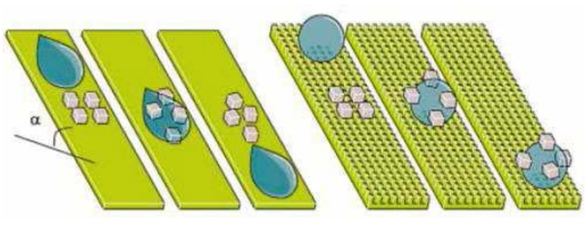

Figure 1: *Nano-enabled textiles self-clean by removing dirt with water (lotus effect). Source: Malik, ,2008* [4]

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well being of driver and passengers. Filters must remove materials, like pollens, spores, harmful substances and dust, which can be source of diseases and allergies. Novel filters using nanofibres have the potential to offer superior capabilities compared to conventional products such as a large surface area while maintaining porosity to remove harmful substances and greatly improve air quality and safety. However, at the moment nano-fibres are cost prohibitive for such uses.

Antimicrobial/antibacterial properties - Textiles with antimicrobial or antibacterial properties could be attractive for the automotive sector. They can improve hygiene within the car interior and contribute to eliminating unpleasant odours. A nanotechnology based, passive, approach is the use of silver (Ag) nanoparticles that are effective against a broad spectrum of bacteria when added to the surface of textile. Such textiles could find demand within the automotive sector.

Antistatic properties - Synthetic fibres possess poor anti-static properties, but fabrics containing electrically conductive nano-sized materials, like titanium dioxide (TiO_2), zinc oxide (ZnO), antimony-doped tin oxide (SnO), have been proved to be effective in dissipating accumulated static charge. These approaches have yet to be considered by the automotive textile industry but could be a viable alternative in future applications.

Flame resistance/retardant - In contrast to the current halogen–antimony and phosphorus–bromine combinations, which besides having limited performance have environmental implications, nanocomposites containing organically modified clay (montmorillonite) dispersed in selected polymer matrices have attracted considerable attention for imparting flame resistance. They are also effective at low concentrations (5% w/w or less). Nevertheless experts indicate that current colloidal antimony pentoxide, clay and carbon nanotubes (CNT) are more expensive than traditional methods and do not offer a significantly higher level of protection. Therefore, even if they are more environmentally friendly, their use is currently hampered. Further performance improvement or cost reduction (or both) would likely change this situation.

Noise reduction - To reduce noise within the car, a nanofibrous layer of non-woven polyvinyl alcohol layered on fibrous underlay materials may be used. Compared to conventional materials this offers improved noise reduction, while also providing good heat insulation and weight reduction. In order for such an application to be an efficient sound absorber, it has to have a thickness of 40mm[6]. Cost reduction of these nanofibres is, however, necessary before adoption in the automotive sector.

Tear and wear resistance - SiO_2, Al_2O_3, ZnO nanoparticles and CNT are the most widely used nanomaterials to improve tear/wear resistance. They can be mixed to many fibres precursor polymers such as polystyrene, polypropilene, or polyvinyl alcohol before spinning, or alternatively, applied to fabrics by spray or dip coating. Currently the industry is looking to find ways to best encapsulate nano-particles to ensure a coating that lasts for the full lifetime of the car.

UV resistance - There are SiO_2, Al_2O_3, and ZnO nano-enabled textile coatings being tested by the automotive industry to protect textiles from UV damage. Again methods for nano-particle encapsulation to guarantee that the coating lasts during the entire lifetime of the car must be found.

These features can be combined providing textiles with multiple functionalities that offer advantages in terms of cost and/or process simplification.

Much of this activity remains at R&D level, but some nano-enabled textiles have reached the market including: RUCO-Guard UCS finishing of Rudolf GmbH[7]; the textiles with the NanoSphere® finish produced by Schoeller[8], presenting a naturally self-cleaning effect; and the Tencel™ material based on nanofibrils of cellulose produced by Lenzing[9], which combines a good moisture management, reduced energy consumption, reduced growth of bacteria, antistatic behavior, and heat absorbing properties compared to common polyester making the material a good candidate for seat car covers. The nano-modified microfibre Evolon by Freudenberg[10], used for headliner, dashboard, carpet backing, doors and the underbody shield, allows a weight and thickness reduction and better noise absorption. Elmarco's NanoSpider Acoustic Web offers similar sound reduction in addition to heat insulation and weight reduction[5].

Spectacular developments can be expected with the introduction of smart textiles. These materials bring an additional dimension of functionality with sensing and actuating capability making them reactive to external stimuli[11], thus opening unprecedented possibilities for the automotive sector.

Prototypes, trying to combine aesthetics with technology, have been produced with the following features; light emitting, light reflective, EMI/RFI shielding, and antistatic properties[11]. A bulb light fabric named ReLIGHT has been produced by GradoZeroEspace[12] providing an integrated soft illumination in car interior. Other futuristic examples of nano-enabled integration of electronics into textiles can be expected These include: sensors to alert the seat to the occupant's body size; and temperature and driving monitoring.

Fabrics have also been developed to monitor the cognitive status for commercial truck drivers, public transportation, and individual drivers[11]. Further examples include: climate controlled car seats based on thermoelectric materials that convert electricity directly into heating or cooling[13]; and monitoring of position and bodily function.

In the short term, nano-related textiles for the automotive sector will mostly deal with comfort and functional issues providing self cleaning, antimicrobial or wear resistant textiles.

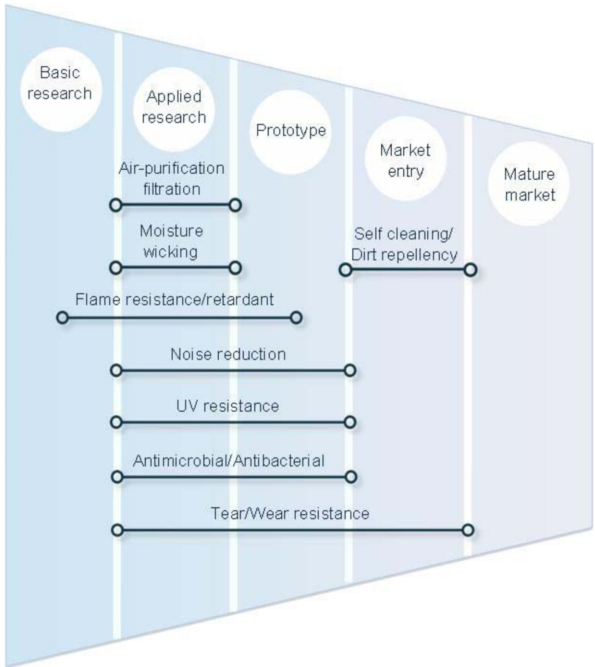

Figure 2: *Technology Readiness Levels for nano-enabled automotive textiles.*

Impacts

Economic/Industry

According to a study produced for the German Bundestag nanotechnologies are included in the future core capabilities crucial to maintaining international competitiveness[14]. The 2008/09 financial crisis caused global light vehicle production to fall from 67 million (2007) to 56.6 million (2009), with a more considerable reduction in Western Europe (16.1 million in 2007 down to 11.3 m. in 2009)[15]. However, the United Nations estimate that the world-wide vehicle fleet will double from 750 million today to approximately 1.5 billion utility and passenger vehicles by 2030 due to increasing demand from the rapidly growing markets of China, India, Korea, Brazil and Russia representing a huge, growing market for automotive textiles.

The volume of textiles in cars is expected to increase drastically and some predict nanotechnology will impact on almost every textile currently utilised here. This will pose a burden on manufacturers because the machinery and training necessary to allow a regular textile manufacturer to begin producing nano-enabled textiles will vary from very minor to very complex, depending on the methods being utilised. This may be the limiting factor in adoption of these technologies.

Societal Impact on European Citizens

The textiles industry still has a relevant role in Europe, both in terms of employment and revenues. The competition in this sector has been very tough over the past year, eroding the position of the European industry in the sector. Nano-enabled textiles can contribute to facing this competition providing new and innovative products, defending existing manufacturing, and opening new markets thus protecting crucial jobs.

Moreover, nano-enabled textile replacements can have a significant, albeit indirect, impact on the environment as well. As stated earlier, by 2020 the increase in textiles being used in cars is expected to reduce the average weight of a mid-range car by 30kg; given their unique properties nano-enabled textiles can contribute to attaining this goal. This weight reduction is estimated to reduce CO_2 emissions by 2.2g/km/car[16]. This would lower current annual European vehicle emissions by over 7.7 million tonnes[17] contributing considerably to emissions targets for 2020.

Challenges

Comfort, safety, and reduction in fuel consumption are some of the challenges facing the automotive industry. Nano-enabled textiles can contribute to here; however, these innovative textiles have to compete with established products with potential trade-off risks. The automotive industry is cost and reliability driven and the advantageous features, provided by nanotechnologies, have to be as reliable in actual series production and cost effective.

Since price/performance ratio is a key driver, the current cost of nano-enabled products could slow widespread adoption. For example, although it may be possible to offer nano-fibre filtration systems, it is currently cost-prohibitive to be mass produced and thus limited research is underway in this area. The introduction of new materials that have improved characteristics, good aesthetics, comfortable behaviour, but that are more expensive, can be motivated by estimating the perceived quality increase that would make the price increase acceptable.

Ethical & societal

There may be privacy issues related to smart textiles that monitor cognitive and health status of drivers depending on who has access to that data. Otherwise, no information has been identified which suggests that the developments highlighted will give rise to specific ethical or societal issues.

Environment, health & safety issues

Dealing with potential health and/or environmental drawbacks is fundamental. Textiles

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lose weight during use as a result of abrasion, irradiation, water, sweat, washing detergents or temperature variations. Therefore it cannot be ruled out that nano-particles may be released from nano-enabled textiles and a systematic investigation on the influence of released nano-particles to health and the environment is paramount. This must be extended to the entire life cycle of these textiles, including recycling.

Safety is a major issue that automotive textile manufacturers must resolve to market their products; research is underway to improve encapsulation of nano-particles to ensure coatings last for a car's entire lifetime. The combined issues of cost reduction, nanoparticle loss and safety are major challenges that must be overcome.

Many laud Europe for taking the most steps to safeguard nanotechnology's impact. While REACH regulations may have improved the EU's EHS standards, some nanotechnology textile companies note that observing these rules may damage their market position. Some experts indicate that rules and standards must be based on an objective evaluation of a nano-product's "true risk" based on normal use versus unrealistic and extreme situations that are very unlikely to happen. Excessively precautious rules could potentially keep European companies from launching new products while enabling foreign products to invade the market. Harmonizing regulation is considered fundamental to assure product safety and avoid unruly competition.

EU Competitive Position

The EU car industry remains one of the most advanced and competitive in the world. To continue as a world leader, there is demand for the most cutting-edge technology and is likely to drive future nano-enabled textile industry developments. Research in nano-related textiles is, in the EU, quite competitive and there is also an extended commitment at industry level with products already on the market. However, competition is strong and a continued commitment to R&D in this field is essential to keep pace with competitors.

Summary

- The automotive sector can benefit from nano-enabled textiles, both in terms of passenger needs and environmental impact.
- Nano-enabled textiles provide new and innovative solutions for car upholstery with moisture wicking, self-cleaning, antimicrobial and antistatic properties, or tear/wear resistance and noise reduction features.
- Safety can also be enhanced with nano-enabled textiles possessing valuable flame retardant/ resistance properties.
- In the more distant future, "smart textiles" that can monitor variables such as the driver's condition; however, privacy issues may arise.
- The increased use of textiles in the car contributes to the reduction of the car weight and hence fuel consumption and CO_2 emissions. Nano-enabled technical textiles offering innovative, often unique, features can favour the tendency of a more widespread use of textiles by the car industry.
- Innovative automotive textiles have to compete with established products. Their current high cost could slow widespread adoption.
- The European car industry remains one of the most advanced and competitive in the world. It will continue to demand cutting-edge technology and this is likely to help drive future nano-enabled textiles industry developments.
- The enabling features of nanotechnology could provide a competitive edge for Europe in the current difficult financial situation.
- Widespread use of nano–enabled textiles in the automotive sector hinges on ensuring the safety for health and environment of such products along their entire life-cycle.

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