innorubber	INTELLIGENT AND MULTIFUNCTIONAL RUBBER COMPOUNDS/ADHESIVES FOR THE SHOE INDUSTRY

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PUBLISHABLE EXECUTIVE SUMMARY

The **main objective** of the project titled "*Intelligent & Multifunctional Rubber Compounds/Adhesives for the Shoe Industry* (INNORUBBER)" is the development of new rubber compounds for outsoles and specific adhesives with properties similar to those of the conventional materials currently used. The aim is to **avoid the surface preparation of soling materials prior to bonding**, or at least to reduce it as much as possible, thus simplifying the overall bonding process.

Surface preparation of substrates has become extremely important in footwear prior to adhesive bonding and this subject has received much attention over the years. In fact, an unsuitable treatment would imply unsticking problems during use or even during the storage of the shoes, which may cause complaints and returns or refunds, resulting in great financial losses for the company.

The use of rubber compounds for outsoles in the shoe industry has allowed a continuous progress in fashion as well as in technology, but it has caused, at the same time, some problems related to bonding of upper materials. Elastomers are, in general, substrates that show low surface energy (around 30 mJ m^{-2}). For this reason, it is necessary to resort to surface treatments that allow the bonding to other substrates ensuring good adhesion forces. The main effects of a surface treatment are stated below:

- Elimination of pollutants and substances capable of forming weak layers likely to fail.
- Creation of specific groups in the substrate surface promoting chemical adhesion.
- Increase of surface area improving the mechanical adhesion (adhesive anchorage).
- Increase of the surface energy of materials.
- Improvement of the surface Wettability.
- Others.

The stronger adhesion of bonds between mechanically or chemically treated surfaces is based on the enlargement of the effective surface (contact surface between the adhesive and the substrate), and on an increase in the number of pre-active sites, enhancing the interactive forces in the interface adhesive/surface.

Surface preparations used in footwear factories can be comprised of different techniques, which can be used alone, or sometimes in combination with others. These treatments usually involve mechanical roughing and/or the use of solvent and chemical treatments (halogenation) which can be harmful to workers, especially when working with rubber material, which is one of the polymeric materials most frequently used in the footwear industry as sole material (23% of soling materials world consumption in the year 2000, and a similar market weight is expected till 2005). Although this is a critical stage for the obtaining of adequate bonding parameters, this treatment is generally done in shoe factories by hand, prolonging production times and adding costs to the final product, which is losing competitiveness in relation to the competition of countries with low labour costs (Far East, Latin America, Eastern Europe).

Therefore, in all cases, the application of a surface treatment, irrespectively of its nature, means the realisation of one critical operation that this proposal tries to avoid by modifying rubber compounds and adhesives. This project intends to increase the compatibility between adherent-adhesive by obtaining *multifunctiona*l materials.

The *intelligent-multifunctional materials* have been obtained through physical and/or chemical modifications (formulation, functionalisation and/or synthesis of base polymer) in soling materials and adhesives, in order to improve the compatibility between them:

- *Formulation.* Adding several additives may adequately modify properties of rubber compounds and adhesive formulations. These additives are either useful or even necessary for the actual process, or they contribute in a effective way to the properties of the finished products. In most cases, these additives, such as plasticizers, are **responsible for the low surface energy of rubbers.**
- *Polymer blending*. Several blends of different polymers have been systematically researched to determine the effect of one polymer on the other one. In other sectors, modified polymers are used to improve adhesion of common materials to metals or other subtracts. In the INNORUBBER project, blending with these commercially available modified polymers will be studied.
- *Functionalisation.* The properties of an adhesive or a soling material may be adequately modified by functionalisation of the base polymer. In the INNORUBBER project, the base polymer is modified to introduce pre-activated reactive sites in their molecules (OH, COOH, NH groups, etc), which are more compatible with the other material of the adhesive joint.

In this project, new soling materials based on SBR, SBS, NBR, EPDM and TPO compounds have been modified, as well as, polyurethane, polychloroprene and polybutadiene (hot-melt) adhesives in order to increase the interactive forces in the interface adhesive/surface, it means, adhesion properties.

As a result of the project, different rubber compound/adhesive systems which comply with the footwear materials specifications and requirements avoiding surface treatment prior to upper-to-sole bonding have been obtained. In most of cases, chemical surface treatments such as halogenation and ultraviolet treatments, as well as, mechanical treatments such as roughing can be eliminated.

Industrial suitability of new materials has been demonstrated and they could be obtained using conventional manufacturing processes with slight adjustments.

Footwear manufactured using intelligent-multifunctional rubber compounds and adhesives complied with footwear requirements about upper-to-sole resistance and durability.

Therefore, the main objective of this project has been successfully achieved. New rubber compounds for outsoles and adhesives have similar properties than the conventional materials currently used. Nevertheless, it is feasible to avoid **the surface preparation of soling material prior to bonding**, or at least to reduce as much as possible the need of it, and simplify the overall bonding process.

The advantages of the elimination of the surface treatment are obvious as there is an important reduction of production times and production costs, which implies a reduction in labour costs and thus the improvement of the European footwear companies competitiveness.

The main achievements of the project have been:

- At the beginning of the project, **Benchmarking** with bonding systems currently used by leading footwear manufacturers worldwide was prepared. According to this information, the rubbers most frequently used in the footwear industry as soling materials (vulcanised and thermoplastic rubbers), and the most common commercial adhesives, mainly polyurethane and polychloroprene adhesives, and standard formulations of these, were selected.
- Identification of the main routes of modification for each material (rubber compounds and adhesives).
- Modification of rubber compounds in order to obtain improved adhesion properties.
- Modification of adhesive formulations in order to obtain high compatibility with rubber compounds untreated surface.
- Different modified SBR/adhesive, EPDM/adhesive, SBS/adhesive and NBR/adhesive systems avoiding surface treatments have been obtained at laboratory level.
- Industrial validation of intelligent-multifunctional rubber compounds/ adhesives systems developed previously at the laboratory
- New rubber compounds can be prepared using conventional mixing processes with slight modifications at SMEs.
- New adhesive formulations can be prepared using conventional mixing processes at SMEs.
- Footwear manufactured using intelligent-multifunctional rubber compounds/adhesive systems developed complied with footwear requirements about upper-to-sole resistance and durability.
- Socioeconomic and environmental impact of the project have been assessed.
- Diffusion of project results to European footwear companies.

Project partners are:

- GALLARDO(ES)
- ANALCO (ES)
- ALEJOS (ES)
- ENECOL (ES)
- FORMA (GR)
- TIGAS (GR)
- CF (IT)
- DIAP (IT)
- INESCOP (ES)
- UPV (ES)
- ELKEDE (GR)
- UNIPG (IT)

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More information about the project can be found at: http://www.innorubber.inescop.es

The project logo is the following:

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