Vamp Tech + PREMIX : ANTISTATIC COMPOUNDS FOR INNOVATIVE APPLICATIONS

BACKGROUND

Thermoplastic compounds are progressively replacing traditional materials (metals, ceramics, thermosetting resins, wood, etc.) in an increasingly wider number of applications, providing cost effective solutions with equal technical performances and introducing major advantages such lower specific gravity, recycling capabilities and staining.

Further, it is now possible to satisfy the various design demands by appropriately choosing the combination between the polymer (which can vary between an economic but technically limited base, such PP and PS, or a very perfoming one, such PPA or PEEK) and the very wide range of available additives, (glass/carbon fibers, mineral charges, flame retardant additives, antistatic charges, stabilizers, etc.) which allow to achieve specific surprising and technically sophisticated performances.

Insulating properties of Plastic

Traditional plastic materials are, by their nature, both thermally and electrically insulating and this feature represents a technical advantage for many applications, but it can be a limitation in substituting metals in situations where antistaticity or conductivity are a design demand (see figure 1 about surface resistivity measurement as an index of antistaticity of a material).

Surface resistivity measurement

Surface resistivity of a thermoplastic material is, as the name implies, the resistance to the flux of electric current over its surface. Most common measurement standards are ASTM D257 – IEC 60093

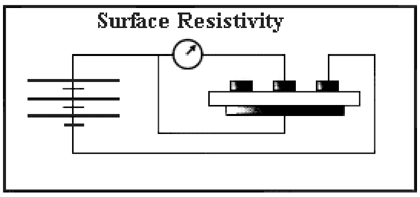
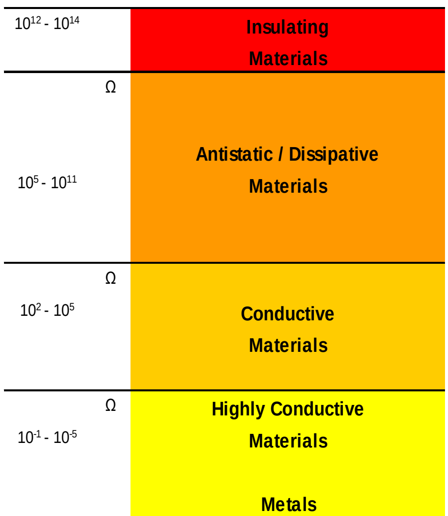


figure 1

However, this limitation can be effectively overcome by making a thermoplastic compound containing specific additives which impart to the compound levels of surface resistivity varying, according to the nature and amount of additivation from 10^{-4} Ohm (typical of metals) to 10^{14} Ohm (typical of insulating materials). It is then possible to use compounds in a wide range of applications which require aimed electric performances (see figure 2).



Definizions based on standard IEC 61340-5-1

figura 2

Further, thermoplastic compounds with surface resistivity lower than 10^9 Ohm allow to satisfy the demands of ATEX (ATmpsphere Explosive) directive about machine tools and their attachments running in environments at high risk of explosion (see figure 3) such mines and gas, fuel, solvent, cement powder, alluminum, corn, sugar, ect., depots.

figure 3

Traditional Antistatic and Dissipative Additives

In order to produce an antistatic compound, it is possible to make use of a range of additives which allow to achieve materials with a wide range of surface resistivity values and thermo-mechanical characteristics. The follwing is a description of the most important fillers.

Conductive charges and fibers

These additives include conductive carbom, graphite or carbon fibers and allow to achieve a surface resistivity in the range 10^2-10^6 Ohm (permanent) according to the amount and dispersion of the used charges. Fillers act by forming a physical network if there occurs an intimate contact among the fibers or the charges.

Due to this conduction mechanism, it is very difficult with these additives to achieve surface resistivities higher than 10^6 Ohm as demanded by some applications in the electronics field. Indeed, as outlined in figure 4, with low percentages of filler it is not possibile to achieve a network inside the polymeric matrix and the compound is insulating (10^{14} Ohm), while, with amounts of charges as sufficiently high as to generate the network (tipically, higher than 8-10% for carbon fibers and 12-14% for conductive charges), surface resistivity abruptly drops below 10^6 Ohm, thereby not allowing intermediate adjustments of the same.

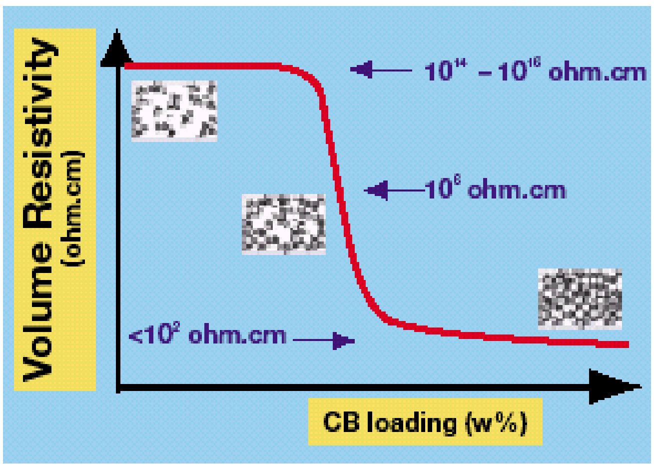


figure 4

These additives are widely used for applications which demand an antistatic or semiconductive compound and can be used with almost all polymers. The use of carbon fibers allows to combine antistaticity with excellent mechanical characteristics and a good level of autolubrication.
Finally, these charges introduce colour limitation since they impart to the compound a grey/black shade which cannot be modified.

Migrating – Non-Permanent antistatic additives

These are hygroscopic additives being blended to the polymeric matrix during compounding and, not being completely compatible with the polymer, tending afterwards to migrate to the surface creating a surface layer able to attract humidity. The presence of water molecules allows to achieve a conductivity as sufficient as to avoid build-up of electrostatic charges. Surface resistivity values achieved are tipically within the range of 10^{10}-10^{12} Ohm. However, once the additive has completed its migration to the surface, and it has then been removed, the desired effect ends, thereby antistaticity is NOT permanent.
These additives are tipically used in packaging and technical items for aesthetic reasons, that is, in order to avoid that the particular charges itself electrostatically and attracts dust during in the early stages of the item's lifetime. An additional advantage offered by this solution is the capability to achieve any colour since the additive does not significantly interfere with the colour tone of the compound.
Examples of migrant antistatic additives are long-chain alkylphenoles, ethoxilate amines, glyceryl esthers.
Though these additives offer a cost effective solution in the short term, they do not lend themselves to be used for applications demanding permanent antistaticity or low values of surface resistivity.

Permanent antistatic additives

These are inherently dissipative polymers (IDP) blending to the base polymer and forming a conductive network inside the former. These polymers allow to achieve a surface resistivity in the range 10^{8}-10^{12} Ohm according to the amount and level of dispersion achieved. In this instance as well, the compound can be easily coloured.
These additives are being increasingly used for packaging electronics components since they allow to achieve a network which protects the component from dangerous electrostatic discharges, but which is also electric-current insulating since surface resistivity is higher than 10^{8}. Moreover, the possibility to obtain bright colours promotes use in antistatic packages which must be easily recognized or ensure aesthetic qualities.
Examples of these additives are block polyetheramides based on PA6 or PA12 and ethilenic ionomers.

Steel fibers

Steel fibers, since long used with various polymeric bases, allow to create a physical network determinating a surface resistivity of 10^{1}-10^{4} Ohm. In this instance as well, the amount and distribution of fibers needs to be effective in order to form the array. Moreover, the compound thus achieved can be easily coloured.
Further, steel fibers allow to produce a compound, and thus artifacts, resulting, by producing a Faraday cage, electromagnetic-wave shielding. This feature makes steel-fiber compounds suitable for making casings ensuring an appropriate protection for components sensitive to electromagnetic fields.

Innovative Antistatic and Dissipative Additives

Nanomaterials – CNT

These are carbon nanotubes resulting, if appropriately dispersed, effective even if added in small percentages (2-3%). They offer the advantage to interfere only to a limited degree with the characteristics of the compound and in particular they do not make it stiffer and/or brittler, as it occurs with fibers and charges.

Technical fields exploring the capabilities of these additives are automotrive (particularly for PA based antistatic fuel tubing) and miniaturized electronics demanding growing protection from (little) electrostatic discharges.

Vamp Tech is committed, together with leading companies in the materials, automotive and aerospace fields, in a project financed by the EC for setting a PPS and PEEK based multi-layer material, reinforced with CNT, aimed to the production of structural parts for various kinds of vehicles.

Metal fillers

The use of high percentages (80%) of copper or low-fusing metal alloys based fibers and fillers allows to produce a metallic network inside technopolymers, such as PA and PBT. In this way, compounds are achieved having electric characteristics which can be compared to those of metals (10^{-4} Ohm surface resistivity) together with an excellent thermal conductivity (about 10W/mK).

These features can for example allow substituting copper paths inside electric and electronics components.

In the table below the advantages and disadvantages offered by the various additives are listed.

Additive	Advantages	Disadvantages
Conductive carbon	Good cost-performance ratio Uniform shrinkage	Difficult control on resistivity Colour
Graphite	Small impact on rheology	Mechanic performances Colour
Carbon Fibers Steel Fibers	Stiffening Autolubrication (for carbon fibers) EMI shielding (for steel fibers)	Anisotropy Colour (for carbon fibers)
Metal fillers	Effectiveness Thermal conductivity	Cost
Conductive Polyemers (ICP)	Easy control on resistivity	Difficult compounding Cost
CNT (Carbon Nanotubes)	Effective at low percentages Low impact on properties	Difficult control on resistivity Cost

Traditional Antistatic/Conductive Compounds

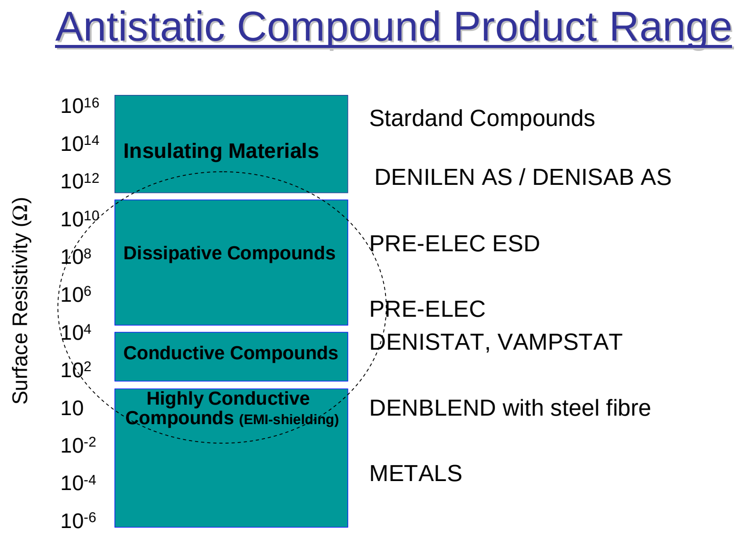
Appropriate use of the above mentioned additives for the production of thermoplastic compounds allows to achieve a range of materials able to satisfy different design demands. In some instances, it may be convenient to use combinations/blends of these antistatic additives to get performances according to the specific design demands.

Antistatic compounds are often enriched with other fillers (glass fibers, elastomers, etc.) allowing to improve the mechanic or thermal characteristics to satisfy specific demands of the customer.

Inovative Compounds: Antistatic + flame retardant
Antistatic fillers, and particularly conductive carbon and carbon fibers, because of their tendency to promote combustion, put great limitations on the production of flame retardant compounds.

Vamp Tech, thanks to its own experience in using flame retardant additives, has overcome these limitations and, during Fakuma 2008, has put on the market a range of PP, ABS, PA6, PA66, PC and PPS based flame retardant and antistatic/conductive compounds, containing flame retardants based on halogens, red phosphoorus and halogen free additives.

Antistatic Compounds product range by Vamp Tech – PREMIX
Thanks to its knowledge and to the commercial and technical partnership with Premix (of which Vamp Tech is the exclusive distributor in Italy and Spain), today Vamp Tech is able to offer an extremely wide range of antistatic and conductive compounds including:



<u>NON Permanent Aantistatic compounds (10^{12}-10^{14})</u>
DENISAB AS (ABS based, non permanent antistatic compound)
DENILEN AS (PP based, non permanent antistatic compound)
Typical applications for these compounds are: chairs, electrical applicances casings, parts of household or garden tools, and, more generally, aesthetic or technical items on where retarding or avoiding dust build-up is desired.

<u>Permanent and Colourable Antistatic Compounds (10^5-10^{11})</u>
PRE-ELEC ESD (compound with dissipative polymers IDP on various polymeric bases).
These compounds are tipically used to produce antistatic aesthetic components or frames for electronic components in which a higher than 10^6 Ohm surface resistivity value is demanded and/or for wich bright scolour is necessary in order to unmistakably distinguish the particulars packaged or being moved.

Antistatic and Conductive Compounds with conductive Carbon (10^1-10^5)
PRE-ELEC (PS, ABS, PE, PP, TPE based antistatic/conductive compounds for molding and extrusion)
These compounds allow the production of aeshetic-needs free (black stain) technical items or packages with a good cost/performance compromise.

Antistatic and Conductive compounds with coal and carbon fibers (10^2-10^5)
DENISTAT (PP, PA6, PA66, PC, POM, PBT, PET, PPA, PPS, PEEK based antistatic/conductive compounds)
Use carbon fibers allows the production of antistatic technical items with high mechanic performance. Moreover, compounds are achieved with good tribological characteristics which allow the production of moving parts (gears, slides, rollers, etc.) which would result particularly prone to accumulate electrostatic charges.
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Antistatic/Conductive + Flme Retarded compounds with and without halogens (10^2-10^5)
VAMPSTAT (PP, ABS, PA6, PA66, PC, PPS, PEEK based antistatic/conductive FR compounds)
These compounds are used to produce electrical devices and components operating in potentially dangerous environments (subject to ATEX directive) and therefore needing to offer high performances in terms both of fire resistance (UL94 V0) and capability of dissipating electrostatic charges.

Conductive Compounds with steel fibers (10^1-10^4)
DENYL, DENISAB, DENIBLEND (ABS, PC/AB, PA6 based conductive compounds)
The presence of steel fibers allows to produce frames or casings for electronic components sensitive to and which can be damaged by electromagnetic fields.

Successful Case Histories

Torch for Explosive environments
Vamp Tech has manufactured the material for the casing for a professional torch. TL268EX torch, manufactured by Mellert, is provided with 9 white LEDs offering a 21,000 mcd luminous intensity. In order to avoid build-up of electrostatic charges, involving high risks when operating in explosive environments, the torch has a PA66 based electrically conductive thermoplastic material casing. The material chosen for the casing is VAMPSTAT Y 00U 05 V0 ST grade, specially developed for this Vamp Tech application. The compound features a 10^4-10^5 Ohm surface resistivity and self-extinguishing capabilities (Ul 94 V0 at 1,6 mm). Melllert torch is suitable for use in environments at risk of explosion in zones 1, 2, 21 and 22 according to ATEX 94/9/EG.

Boxes for Electronic Components

PRE-ELEC® ESD 6300 and PRE-ELEC® ESD 5500 were used to produce trays and boxes for electronic components.
PRE-ELEC® ESD 6300 is an High Impact Polystirene (HIPS) based dissipative compound (surface resistivity 10^8 Ohm) containing inherently conductive polymers. The dissipation capability does not vary over time and the compound can be coloured, allowing to produce boxes with different colour is necessary to distinguish electronic components.
Boxes were produced by extrusion followed by thermoforming of dissipative HIPS sheets.

PRE-ELEC® ESD 5500 is a PP based dissipative compound (surface resistivity 10^9 Ohm). The compound is suitable for injection molding, it contains inherently conductive polymers and can be coloured in bright shades.

GAS/AIR Mixing System

VAMPSTAT Y 25G 04 V0 30 NERO was used to produce a gas/air mixing system for condensation heaters.
Electrostatic charges which can accumulate in components and installations delivering liquid or gaseous fluids can generate electrostatic discharges leading, in the presence of flammable materials, to explosion or damage to sensistive products and devices.
Siemens Building has developed a new gas/air mixing system, for condensation heater installations, with performances in the range 10kW-40kW.

In partenership with Vamp Tech, european leader in conductive and flame retarded compounds innovation, a compound was developed offering auto-estinguishing behaviour, UL 94 V0, and low surface resistivity satisfying new generation heaters and burners' technical demands.

These performances are supplemented by an economic advantage afforded by the optimization of the production as a consequence of thermoplastic compond injection molding as an alternative to use of metal.

Conductive Monofilament

PRE-ELEC® PP 1396 compound allowed the production, through extrusion process, of antistatic monofilaments suitable for various applications. Antistaticity was achieved with high performance conductive carbon..

Further, this compound was developed in order to sustain 5/6 time stretching in the extrusion and spinning machine allowing to achieve excellent mechanic characteristics as well as good processability and an antistatic filament.

Antistatic Hoses

PRE-ELEC® PE 1291 compound allowed the production of co-extruded tubes, operating under pressure, with antistatic internal and external surfaces. These tubes were produced for gas delivery, but they lend themselves to deliver combustible powders, granules, vacuum and venting tubing.

The excellent processability achieved allows to optimize antistatic coatings thickness allowing to optimize the tubing cost-performance ratio.