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DISSERTATION ON THE ELECTRIC AND ELECTRONIC USAGE OF TECHNICAL PLASTICS

Otto-Paul Eberst, North University of Baia Mare
Sever Pop, Proned Control Baia Mare
Elena-Angela Pop, North University of Baia Mare

Abstract: *In this work we will present the plastic materials used in electronic industry and their applications. We'll investigate the electrical isolation capabilities of polymers regarding their material structure.*
Also, we'll analyze characteristics of those plastic materials which are not conducting the electricity.
Keywords*: semi-finished plastic products; electrical and electronic industry; conductive plastics*

1. INTRODUCTION

After the spreading of world-wide mass polymer production, with the appearance of technical plastics it became possible to have more industrial applications using the favorable mechanical, thermal, chemicals resistance and tribological characteristics of polymers.

Beyond those characteristics many times is also very important the performance of polymers under electricity and to find out what kind of screening characteristic develops in an electromagnetic field with changeable frequency.

Usually if we talk about electric characteristics of plastics we think of 2 main possibilities: or the polymer's isolation capability must be best as possible or it should not isolate at all (to conduct electrons under a determined resistance) for a certain reason.

According to that in this work we shortly compell regarding technical semi-finished plastics the followings:

- the main characteristics of polymers used for classic, strong electric applications, and the descriptions and measurements of usual comparisional characteristics,
- the new groups of items, products used in the semi-conductor and electrical industries.

2. ELECTRICALLY NON-INSULATOR PLASTICS

True: the plastics entered in the public conscience as traditionally isolator materials but the fast development in material science was motivated by many reasons: at numerous

new procedures like the holder of electronic devices - is basic requirement the screeing electro-magnetic effect or the protection against electrostatic chargeing became critical, fire- and blast-dangerous working places, production of electronic spare parts – this is how appeared the category of non-isolator plastics which it behaves peculiarly from an electric point of view.

Specialists developed two basic orientation about the making of quality heat and electrically conductive plastics:

- making them by modifying their electron structure;
- the induction of conductive additives in a way that beside acquareing good heat and electric conductivity not to fault/harm even in a smallest percentige the physical and mechanical parameters of the polymers' matrix.

The most used practice to compare polymers - according to the characteristics showed at the first point – is the comparison between the resistence of surface areas for getting the anti-static characteristic. The earlier names given by producers did not stated separately the 10^2-10^{13} Ω materials but used for all of them the anti-static attribute.

Electrically conductive plastics by modifying the electron' s structure

In this category fits plastics which turned out to get an electronic conductivity-helper π- electronsystem. This type of structural bound/tide is obtained or by choosing the right monomer (like polyens) when making the structural type or the polymer or by the chemical transformation of the big molecule(pirolyzis).

The main representatives of conjunctive π- electronsystems are:

- polyphenylens and their products;
- polymers made from aromatic and hetero-periodical compounds;
- interchanging the class of aromatic and uncharged polymers;
- ring-type closure-made polymers;
- polymers obtained by pirolyzis.

Electrically conductive additives

If we mix additives which are conducting electricity with plastics, the specific resistence of them is falling and they become conductible. The morphology, type, quantity, the mixing mode all are influenceing the conductivity characteristics of materials. The

additive can be: carbon deposit, graphit, creyon (carbon line), powders, flakes, disks, filaments, metal coated graphit, fibreglasses, metal coated glass pearls and their combinations. In any case there's a need for reaching the so called critical concentration which means reaching the continuous net structure evolved from the basic matrix.

The conductivity and processability of plastics partenered with relatively cheap chrom can be set between wide limits by chooseing the right type and quantity of carbon deposit. The conductivity near same charging ratio is increasing directly proportional with reduceing sizes of the small particule, its structure and with the chemical cleaness of surface.

2.3 Typical applications of electrically non-insulator (conductive) polymers

The main applicational areas for electrically conductive plastics are:

- the elimination of electromagnetic (EMI) and radiofrequency interferences (RFI) by electric screening,
- the stopage of electrostatic charging;
- new constructional solutions;
- the use of better heat capability than usual plastics have for heat elimination;
- making the resistence-heating for special tasks.

The electromagnetic and radiofrequency interferency is catalogued as electronic noise. The lowest levels to be counted as noise sources and absorbtion items are: for motor vehicles and household machineries – under 100 MHz, for analogue systems and industrial process-controller(manipulator)devices – between 1 and 50 MHz, for computers and periferics – till 1 MHz frequency. The plastics let through electromagnetic radiation till 100 MHz, propriate screening effect could be reached by induction of electrically conductive additive or by making an electronically conductive surface layer. The screening protects environment from the electromagnetic radiation produced by the device but at same time, the device is also protected against environment factors.

The possibilities of plastics' electric screening and polymers modification are:

- coating of metal foil, metal strip or metal grid;
- vacuum steaming;
- cathode dispersion;
- silver reduction;
- flame dispersion;
- (electric) arc dispersion;
- usage of electrically conductive additives.

3. NON-INSULATOR APPLICATIONS OF TECHNICAL PLASTICS

In the commerce we are able to reach more and more composit materials, semi-refined polymers with their surface beeing coated. The no. 1 figure underlines the most important anti-static, ESD and conductive polymers made by Proned Control Ltd. categorised according to their traditional mechanical and heat charge. The second mode of categorisation is called by the scientific world „material pyramid".

The no. 2 figure shows the main anti-static, ESD and conductive semi-refined plastics categorisation according to their electric resistance, plastics all made by Proned Control.

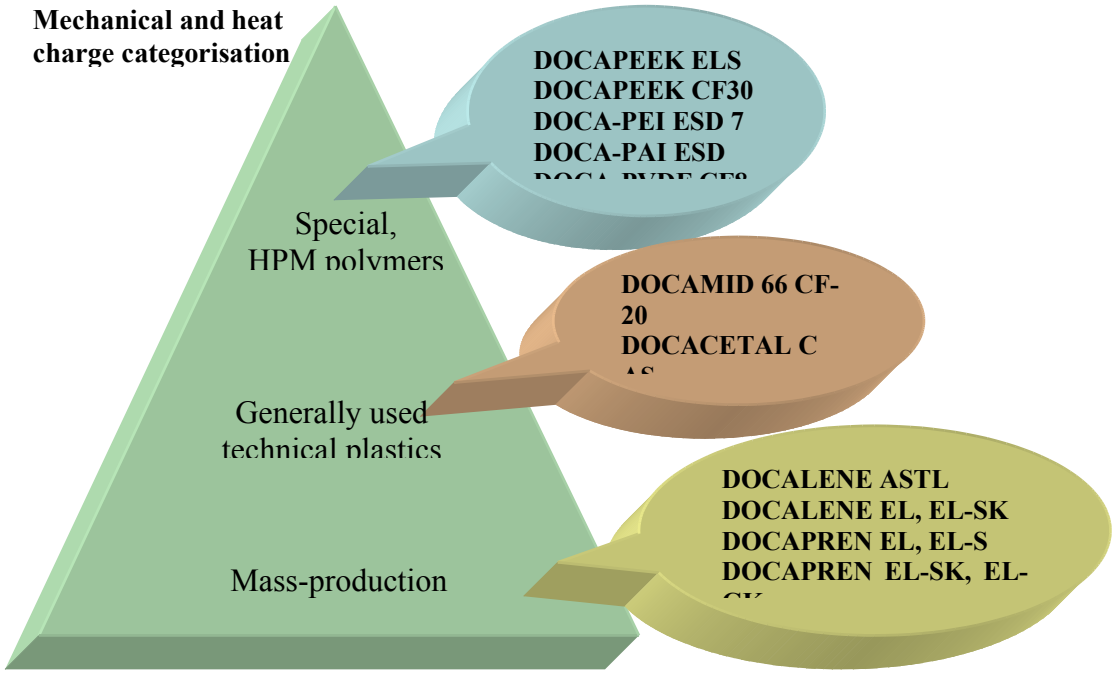

Fig. 1 Semi-finished technical plastics for non-insulator applications

3.1 Non-insulator composits of industrial-scale production polymers

Polyethylens

DOCALENE ASTL, Black, green. UHMW-PE HD 1000 material quality. It have one of the best abrasive friction resistance and toughness in the HD 1000 materials' category. Due to its low resistance is rather mentioned in the electrically conductive category. It is protected against UV radiation. Thanks to these characteristics it become very requested ranging in fields from electronic industry till material displacement.

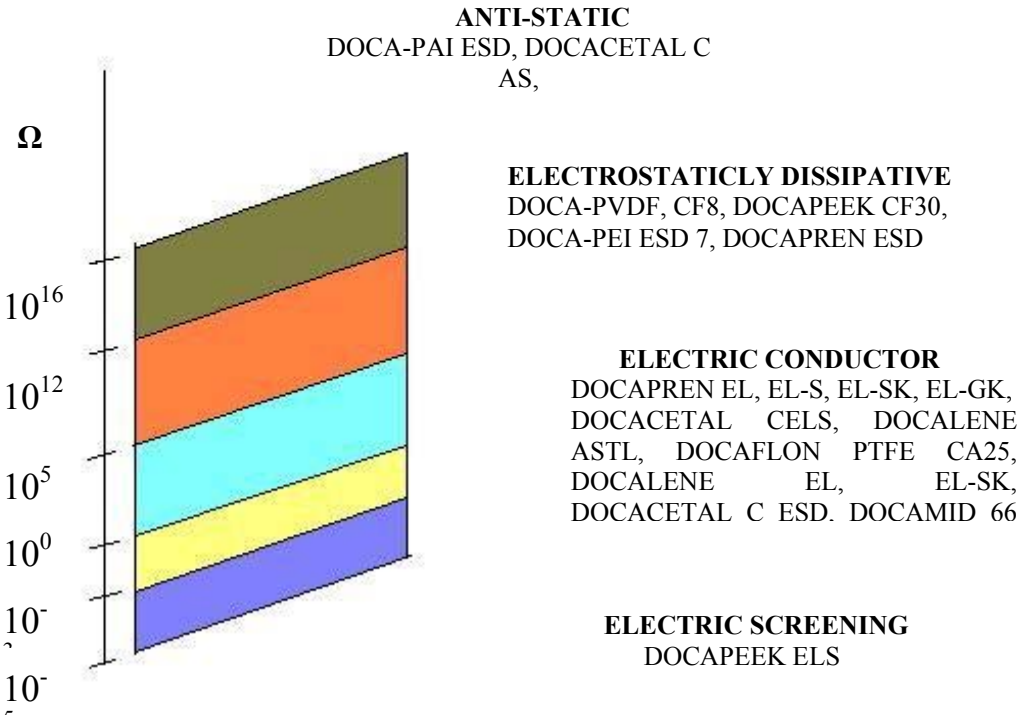

Fig. 2 Classification by their surface resistance (Ω)

DOCALENE EL, Black. It is a polyethylen which fits in the quality category of increased heat resistance, UV stabilised and with HD 500 mol mass. It's a plastic from the category of electrically conductive ones. Beside chimical industry applications, it's used for making holder tanks, in grain industry applications and in explosion-dangerous places is used as electrically conductive („anti-static") polymer.

DOCALENE EL-SK, Black, covered (incased) with polyester. Same as the Docalene El it has an enhanced heat resistance and it is an electrically conductive polyethylen having the surface covered in polyester. It is used to make different covering surfaces for electronic industry.

Polyprophylens

DOCAPRÉN AS, Natural. It's a homopolymer polyprophylen, a durably heat-stabilised material. It's in the category of anti-static plastics. Main areas of use includes tools

production for chemical industry and in the textile and garment trade. Physiologically is neutral – also used in the food-processing industry. It can be transformed well by cutting.

Table 1 Main material characteristics, non-insulator polyethylens

Characteristics	ISO examination	Unit	DOCAL ENE EL	DOCALE NE EL-SK	DOCALE NE ASTL
Basic colour			black	black	black, green
Density	1183	g/cm³	0.99	0.99	0.96
Mechanical parameters on 23 °C					
Tearing examination, -breaking resistance -elongation at brake -modulus of elasticity	 R 527 R 527 R 527	 N/mm² % N/mm²	 26 50 1100	 26 - 1100	 20 >300 770
Solidity against notched hitting and bending: - Charpy	 179	 KJ/m²	 5	 5	 Not breaking
Surface resistance	IEC 60093	Ω	$< 10^6$	$< 10^6$	

DOCPRÉN EL, Black. It's a homopolymer polyprophylen, categorized as electrically conductive plastic. It's used for making electronic devices, used in the packing industry, equipments from chemical and machinery industries, for covering surfaces.

DOCPRÉN EL-S, Black. It's the burn-stoped variation of the DOCAPRÉN EL being used in case of enhanced fire-security regardments for electronic and chimical industries.

DOCPRÉN EL-SK, Black covered (cased in) polyester. It's the surface coated variation of the DOCAPRÉN EL and is cased in with polyester. It's used generally for devices made in the packing industry, packing materials, where electrical characteristics are important - especially the surface resistance.

DOCAPRÉN EL-GK, Black covered with glass texture. The surface of DOCAPRÉN EL is strengthened with glass texture. It's structural marerial is basicly conductive with general mechanical characteristics and having a strongly improved size keeping capacity. It's used for making covering surfaces for equipment industry.

DOCAPRÉN ESD, Black. It's an electrostatically dissipative polyprophylen produced in bar/rod shape and having a $10^6\Omega$ surface resistance. Comparing with the natural PP it has a bigger mechanical solidity.

3.2 Generally used technical plastics

DOCACETAL C AS, Natural, (black). The product looses it's electric charge by including in the basic POM-C matrix some conductive material. Compared with the natural POM-C this it has a 3 times smaller volume resistance. It is an anti-static POM-C.

DOCATEL C ELS, Natural, (black). Compared with the anti-static POM-C this type has 7 times smaller volume resistance. Electrically conductive POM-C.

DOCACETAL C ESD, Black. If we count it's surface resistance this material is placed in the conductive and electrostatically dissipative category with 10^4-10^6 Ω resistence. It's made in rod form.

DOCAMID 66 CF-20, Black. It's a 66 polyamid with great solidity and carbon fibre reinforced. Main characteristics of this material are: bigger heat resistance, size keeping, small surface and volumetric resistance, so it's included in the category of electrically conductive polymers.

DOCAFLON PTFE CA 25, Black. It's a PTFE charged with (filled with) carbon. It has a very high chimical resistance and it's electrically conductive. Beside reduced friction factor, compared with the matural PTFE it has an improved size-keeping capacity.

3.3 HPM materials with outstanding heat and mechanical parameters

DOCAPEEK ELS, Black. It's a PEEK reinforced with carbon fibre and conductivity improveing other additives. Thaks to the filler it's a good conductive polymer, outstanding material for electronic and half-conductive industries with big heat resistence.

DOCAPEEK CF 30, Black. It has also carbon fibre reinforcement. Due to the improved mechanical parameters and the electric resistance it's counted as an electrostatically dissipative material. Compared with natural PEEK it has a better abrasive resistance.

DOCA-PVDF CF 8, Black. It's a PVDF with carbon fibres too. Electrostatically it's dissipative. Outstanding chemical resistance. It has a better size keeping capability thanks to it's carbon fibre compound than the natural materials.

DOCAPEI ESD 7, Light permeable, braunish. It's the optimal combination of the mechanical, heat and electric capabilities. It's difficult to burn and it's burning makes small amounts of smoke. It's electrostatically dissipative regarding it's resistance.

DOCAPEI ESD, Greyish. It's the composite version of a polyamidimid (PAI). It's counted as an anti-static material on the base of it's resistence values.

Characteristics

The HPM (High Performance Materials) and their composits' mechanical and heat resistance capabilites are not so obviously different as we can see in case of the mass

production materials – in many cases the difference is procentualy insignifient. It's more important the difference in electric and tribologic (friction and wearing) characteristics.

Thanks to this, we do not show the heat resistance and mechanical parameters, for general knowledge you can take the characteristics of natural or looklike insulator composite polymers from the general table.

The important electric parameters are displayed in the no. 2 table.

Table 2 Electric resistance values for HPM materials

Brand name	**Material**	**Volume resistence, Ω cm**	**Surface resistance, Ω**
DOCAPEEK ELS	PEEK	10^2 - 10^4	10^1 – 10^3
DOCA-PVDF CF8	PVDF	10^3 – 10^5	10^5 – 10^7
DOCAPEEK CF 30	PEEK	10^5 – 10^7	10^5 – 10^7
DOCAPEI ESD 7	PEI	10^6 – 10^8	10^8 – 10^{10}
DOCAPEI ESD	PAI	10^9 – 10^{11}	10^9 – 10^{11}

4. CONCLUSION

The knowledges compelled in this work are continuously growing due to the fast expansion of polymer-chemistry and thanks to the changeing needs of microelectronics and energetic industry. It's possible to appear as a new breaktrough smaller resistence materials (under 10^0 Ω**)** and the non-insulater, special composite group will grow further.

Some groups of non-insulator materials made and presented in details by Proned Control are not fullfilling all the reachable possibilities, a significant number of other composit plastics can be ordered based on previous talks.

The engineers of Proned Control are at your service regarding any further questions about the presented items' technical-chemical bases, about it's products and application techniques.

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