

PROCESSING OF POLYISOPRENE-NANOSTRUCTURED CARBON BLACK COMPOSITE CELLS FOR PRESSURE SENSORS

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Natural rubber latex is used as a matrix material. Nanostructured carbon black (mean particle diameter - 30 nm, dibutyl phthalate adsorption - 380ml/100g, specific surface - 950 m²/g) is used as filler. Mixing was performed on cold rolls in Baltic Rubber factory. Raw material was cured in 1*15*120mm slices between two 50μm thick brass sheets in stainless steel mold, using different mold pressures from 10 to 100kg/cm² by step of 10. Resulting product was carefully cut into 10 similar pieces by dimensions of 1*10*15mm each. Each piece represents a sample - piezo resistant sensor cell with regular brass electrodes. The specific electrical resistance of samples was measured in unstressed state (Fig.1). Finally, the piezo resistive sensitivity was determined and conclusions about influence of mold pressure on sensing properties were made.

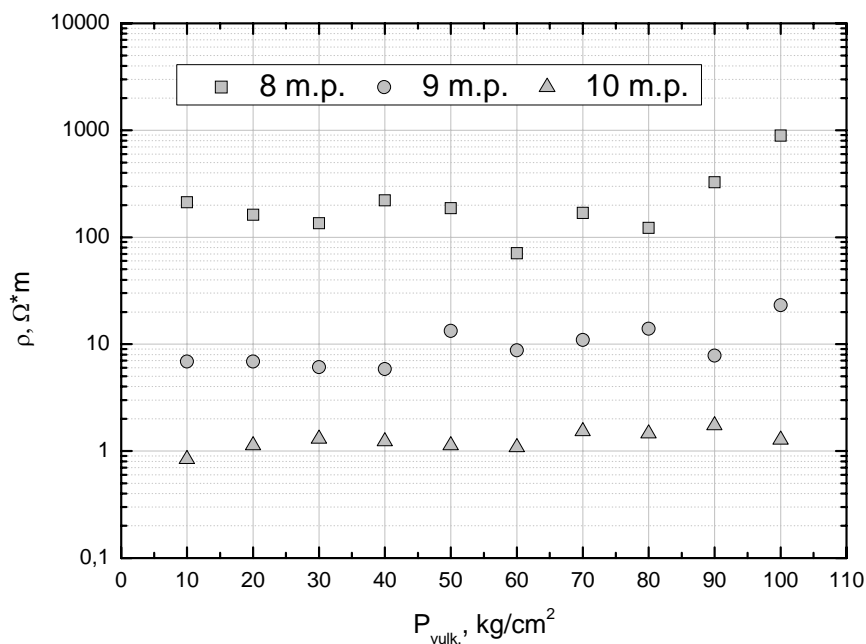


Fig.1. Specific electric resistance of unstressed polyisoprene – nanostructured carbon composite with 8, 9 and 10 mass parts (m.p.) of filler as function of mold pressure.



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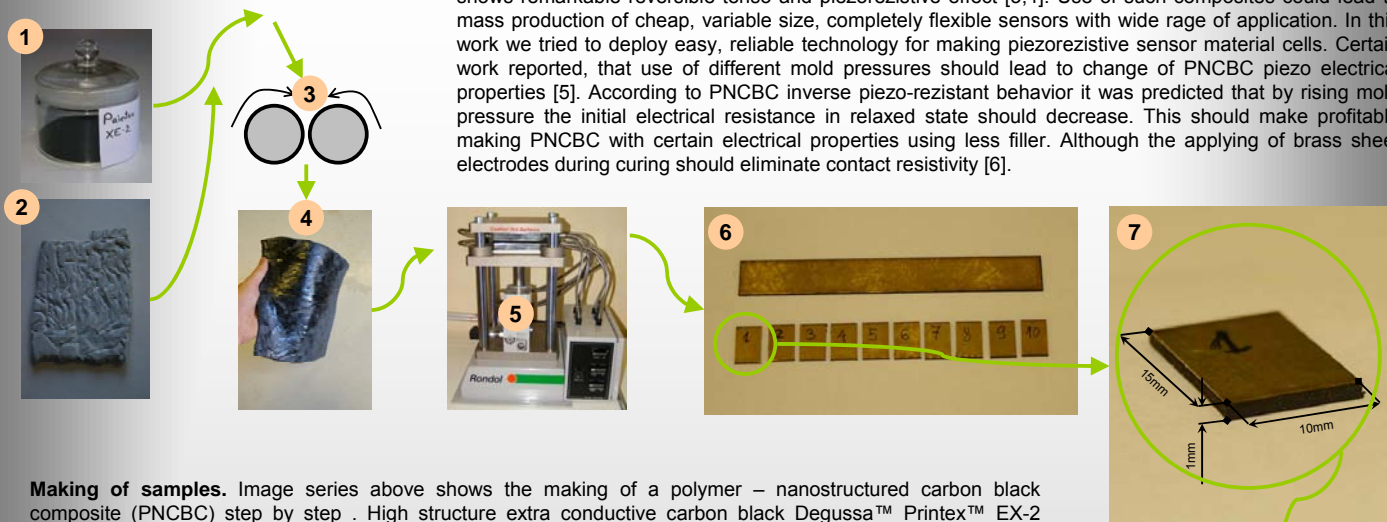
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Introduction. Broad use of compressive and strain sensors requires new materials to be designed for particular application. Recent research approved polyisoprene-nanostructured carbon black composite (PNCBC) to be a perspective material for current needs [1,2]. At certain concentrations of filler PNCBC shows remarkable reversible tenso and piezoresistive effect [3,4]. Use of such composites could lead to mass production of cheap, variable size, completely flexible sensors with wide range of application. In this work we tried to deploy easy, reliable technology for making piezoresistive sensor material cells. Certain work reported, that use of different mold pressures should lead to change of PNCBC piezo electrical properties [5]. According to PNCBC inverse piezo-resistant behavior it was predicted that by rising mold pressure the initial electrical resistance in relaxed state should decrease. This should make profitable making PNCBC with certain electrical properties using less filler. Although the applying of brass sheet electrodes during curing should eliminate contact resistivity [6].



Making of samples. Image series above shows the making of a polymer – nanostructured carbon black composite (PNCBC) step by step. High structure extra conductive carbon black Degussa™ Printex™ EX-2 (image 1) was mixed into thick PaleCrepe natural rubber (image 2) using cold rolls (image 3). Raw material (image 4) with 8, 9, 10 and 11 mass parts (m.p.) of conductive filler was cut into pieces and cured between two 50µm thick brass sheets in hot steel mold using Rondol stomatostated press (image 5). Curing time used $\tau_{1,5}$ was determined by Monsanto™ Reometer100™. 10 sticks (image 6) were cut into 10 to 11 similar slabs using diamond cutter to avoid squeezing sensitive core material. Afterwards the slabs (image 7) were cleaned with ethanol from rubber dust and numbered according to their origin in stick and used as test samples.

Experimental. Initial electrical resistance of virgin samples were measured between custom made brass electrodes (image 8) using Wavetek™ Meterman™ 27XT digital multimeter. Specific resistance has been calculated regarding to slab size. Data collected are represented in graphs below (Fig.1 to 4).

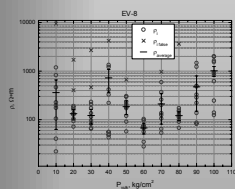


Fig.1 Electrical resistance depending on mold pressure for PNCBC with 8 mass parts of carbon black.

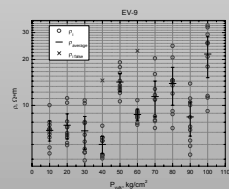


Fig.2 Electrical resistance depending on mold pressure for PNCBC with 9 mass parts of carbon black.

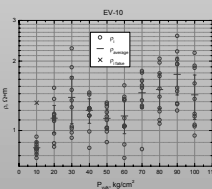


Fig.3 Electrical resistance depending on mold pressure for PNCBC with 10 mass parts of carbon black.

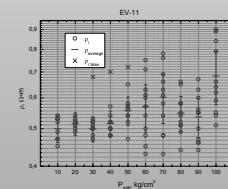


Fig.4 Electrical resistance depending on mold pressure for PNCBC with 11 mass parts of carbon black.

Error values (ρ_i false) were eliminated using statistics and crude error estimation criteria. The arithmetical averages were calculated from accepted values (ρ_i) for each group of samples and is represented as $\rho_{average}$ in graphs. Although the full error of $\rho_{average}$ was determined for each group of samples. Finally all averages were plotted into one graph (Fig.5) for comparison.

Results and discussion. As it is seen, PNCBC has tendency to rise its initial electrical resistivity with increase of mold pressure, and it's reverse what we expected. This fact eliminates the argument, that rise of curing pressure should approximate the filler particles, thus allowing tunneling currents to flow more easily. More likely, pressure is limiting the formation process of conductive network. During this work, reliable technology for making PNCBC cells has been developed. PNCBC slabs with thickness from 1mm to 100µm has been made using this method. The problem with electrodes has been resolved using brass sheet mold bolsters. Determination of sample piezoresistive properties have been planned for near future.

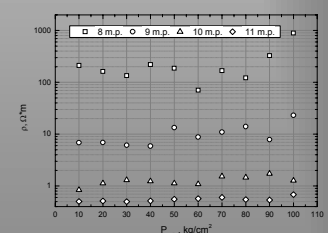
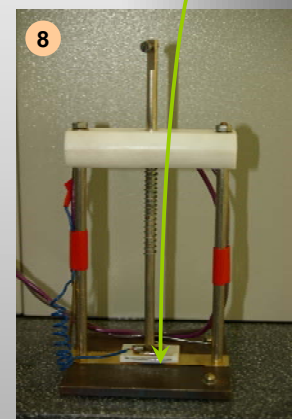


Fig.5 Average electrical resistance ($\rho_{average}$) depending on mold pressure for PNCBC with 8 to 11 mass parts (m.p.) of carbon black.

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