Preparation and Characterization of Conductive Jute Hand knotted Carpet by In-situ Chemical polymerization of Pyrrole

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Abstract:

This work deals with the preparation and characterization of electrically conductive hand knotted Jute carpet for heat generation. Hand knotted jute carpet of different knot density can be made electrically conductive by in-situ chemical polymerization of Pyrrole with p-toluene sulphonic acid dopant. Alkali hydrolysis of hand knotted jute carpet were done before in-situ polymerization for better fixation of poly pyrrole .The average surface resistivities, add-on percentage, current-voltage relationship will be measured as per method. Therefore, the aim of this study is to prepare electro-conductive hand knotted jute carpet after surface modification and to analyse its heat generation characteristics. These electro-conductive textiles can be used as flexible and portable heating pad for therapeutic use. The surface resistivity, voltage-current behaviour, voltage-temperature behaviour and effect of time on conductivity were successfully studied of the electro-conductive hand knotted jute Carpet shows good voltage temperature behaviour. The prepared sample may be used as heating pad for therauptic use and it can be used as flooring which gives good heat retention quality compare to normal hand knotted jute carpet. Heating chamber is successfully prepared for analysis of heat generation of prepared sample. The future scope of work is to improve the durability of the samples and heat retaining capacity of prepared sample.

Key words: hand knotted jute carpet, electro-conductive, in-situ polymerization

1. Introduction

In the late 1970s, MacDiarmid, Heeger and Shirakawa discovered conductive polymers. The first material becoming an intrinsically conducting polymer (ICP) was polyacetylene [1], after a doping with iodine. The announcement of this discovery quickly reverberated around scientific community, and intensity of the research for other conducing polymers magnified dramatically. A new generation of polymers was then developed, exhibiting the electrical and optical properties of metals or semiconductors, at the same time retaining the attractive mechanical properties and processing advantages of polymers. Intrinsically conducting polymers were immediately seen as a new route to mimic metallic conductivity, besides the well-known approach to insert conductive fillers into an inherently insulating resin, or to coat a plastic substrate with a conductive metal solution. In this manner, conductive fibers can be prepared to obtain conductive fabrics, or, fabrics already produced can be metalized with a conductive coating. By the way, let us note that metal coated textiles remain fundamental materials, because they generally show a high electromagnetic interference shielding effectiveness (EMI-SE). In fact, intrinsically conducting polymeric materials can be used to obtain rather innovative textiles. These textiles are able to absorb as well as reflect electromagnetic waves, and then can exhibit certain advantages over metallic materials. Actually, the most prominent ICPs in

EMI-SE are polypyrrole and polyaniline, where electrical conductivity can have values comparable to those observed for poorly conducting metals and alloy. Among the first commercial products incorporating polypyrrole there was Contex, a conductive textile product originally manufactured by Milliken, starting around 1990, and now produced by Eeonyx Corp., as EeonTex™. An early application, involving the coating of polyester fibers with polypyrrole (PPy) was the creation of an antistatic fabric. We will also discuss the heat generation obtained from PPy coated fabrics, for suitable applications in textile heating systems. Polypyrrole is in fact one of ICPs very promising for wide thermal electric applications because of its easy.

2. Experimental

2.1. Materials

1) Handmade knotted Jute carpet (7 x 7 cm^2)

2) Pyrrole (Leonid Chemicals, India).

3) $FeCl_3$ (Qualigens Fine Chemicals, India)

4) PTSA [P- Toluene Sulphonic acid Monohydrate LR] (s d fine-chem Ltd., India)

5) Non-ionic Surfactant

2.2. Methodology

2.2.1 Polymerization

For in situ polymerization, control polyester sample (25cm×12.5cm) was allowed to soak in 0.5M solution of pyrrole in water for 1 hour at room temperature. The bath containingthe fabric was then cooled to ~5^{o}C and 0.25 M FeCl3 along with 0.05M PTSA (dopingagent) solution was added to the bath slowly over a period of 1 hour so as to polymerizethe monomer. The M:L ratio was 1:100. This fabric was then thoroughly washed with sufficient amount of water and allowed to dry at 27^{o}C and RH of 65%. This fabric was black in color resembling polypyrrole.

Chemicals	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**
Pyrrole	0.5 M	0.5 M	0.5 M	0.5 M
Ferric chloride	0.25 M	0.5 M	1 M	1.5 M
PTSA	0.05 M	0.05 M	0.05 M	0.05 M

Table 1: Details concentration of chemicals in sample

2.2. Fabrication of Heating Pad

A PPy coated hand knotted carpet 7 cm × 7 cm is used as heating element. This textile heating element is connected with the negative and positive terminals of a voltage supplier or battery by the following methods as described below.

2.3. Connection with wires

When the objective is to use the heated fabrics in clothing it is preferred to have connections that are flexible and have low contact resistance. For this purpose fine copper strands were used. The strands were separated and spread out on both sides of fabric. A polyester thread can be used to stitch the strands onto the fabric and contact was achieved when the metallic cables were pressed onto the conducting fabric by the thread. The primary advantages of this technique are that the contact achieved is good and the connection is flexible. Now two terminals of this textile heating element have been made for connecting with power supply or battery.

2.4 Construction of Pad and heating chamber

2.4.1. Materials used

Outer layer – Tarpaulin Fabric
Inner lining – fine polyester fabric.
Intermadiate material- PPy coated woolen handmade carpet.

Fig 9: connecting wires attached on fabricated carpet

2.4.2 Heating chamber

Thermometer tolerance - ±1℃

Outer surface

Length - 15.4 cm   Width - 13.5 cm   Height – 16 cm

Inner surface

Length-14.8 cm   Width –9.8 cm   Height -15 cm

Fig. 10 Heating chamber

2.4.3. Method

The whole structure was stitched together with outer shell of tarpaulin fabric, innermost fine polyester lining and the PPy coated PET non-woven fabric was inserted between them leaving connections outside. Nylon tape was stiched around the edges locking the whole structure and Velcro was attached.

3.Results & Discussions

3.1. Weight add-on %

Add on percentage of the sample is given by ratio of difference of final weight and initial weight of sample to the initial weight of the sample.

$$\text{Add on \%} = \frac{\text{Final weight of sample} - \text{initial weight of sample}}{\text{initial weight of sample}} \times 100$$

$$= \frac{26.716 - 22.608}{22.608} \times 100$$

$$= 18.17\%$$

3.2. Surface resistivity

Surface resistivity can be measured using equation number --

$$\rho s = Rs * \frac{2\pi}{ln\left(\frac{R2}{R1}\right)} = Rs\ K$$

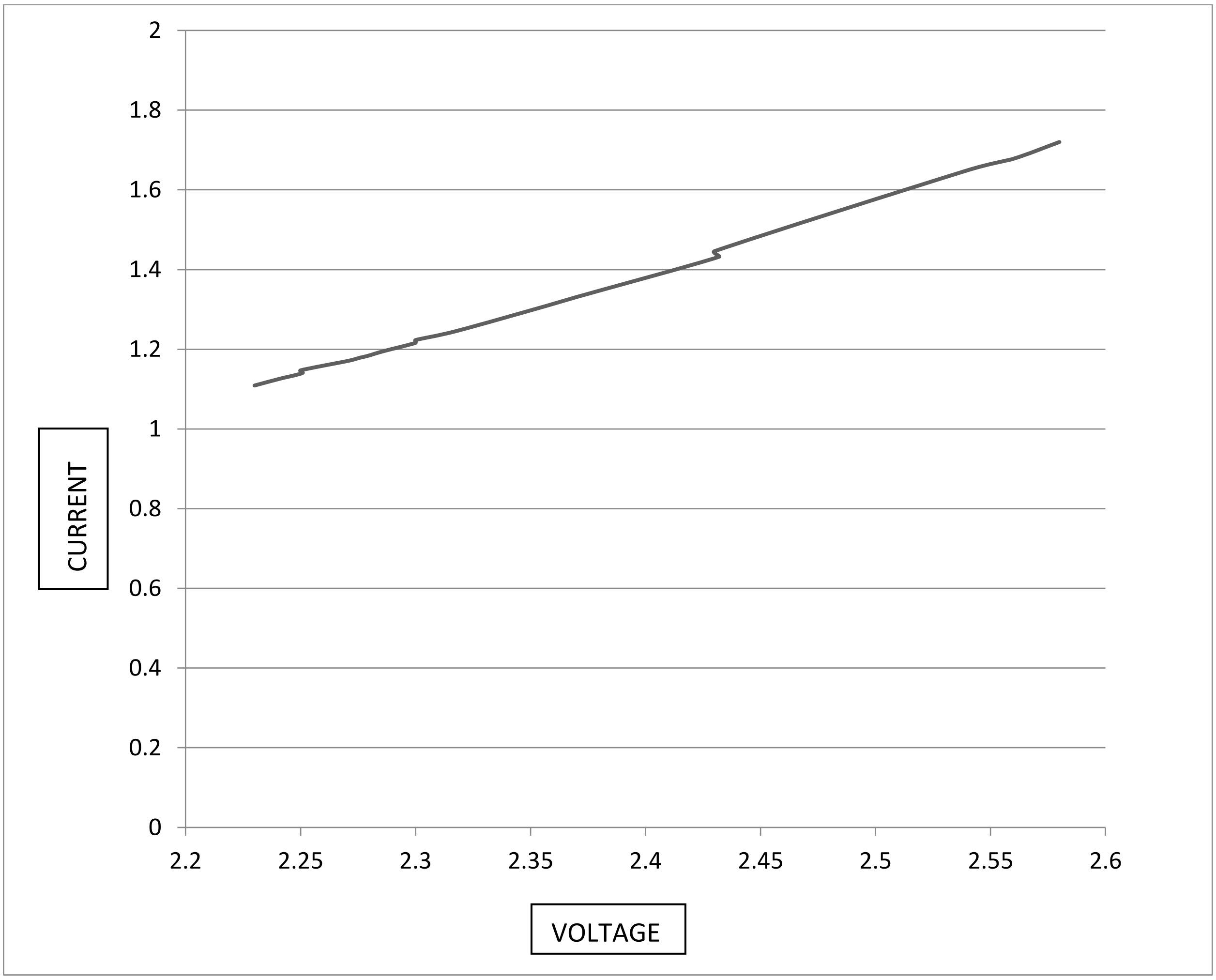
Resistance of PPy coated handmade carpet-

Average resistance **[kΩ]**	**Surface resistivity** **[kΩ]**	**Conductivity** **[kΩ]$^{-1}$**
1.83495	**13.9384**	**0.07174**

Value of constant k = 7.6 (calculated)

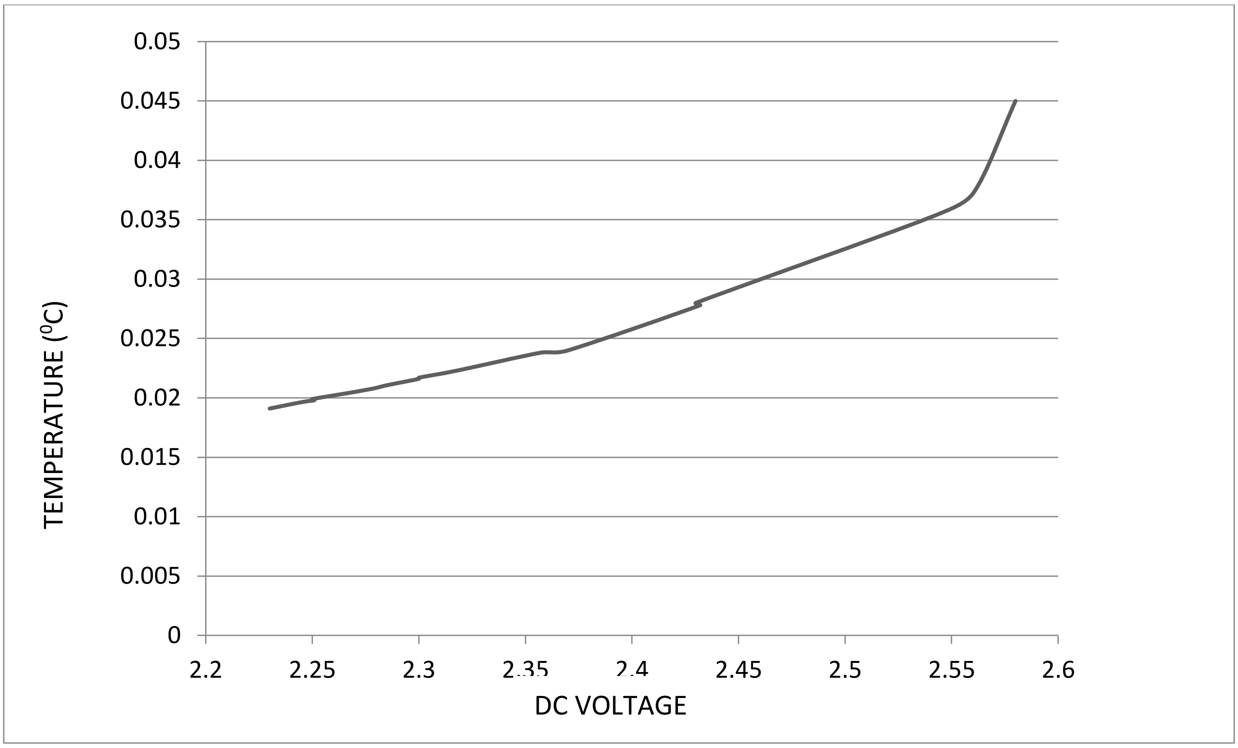
3.3. Voltage-Current characteristics of electro conductive handmade carpet:

The electrical properties of electro conductive handmade carpet were measured at 27^{0}C and 65% relative humidity. The carpet sample (5 cm × 5 cm) was connected with power supply with help of two steel electrodes. The applied voltage was progressively increased and the values of current across the Carpet were noted. Subsequently the current versus voltage curve of electro conductive carpet was plotted.

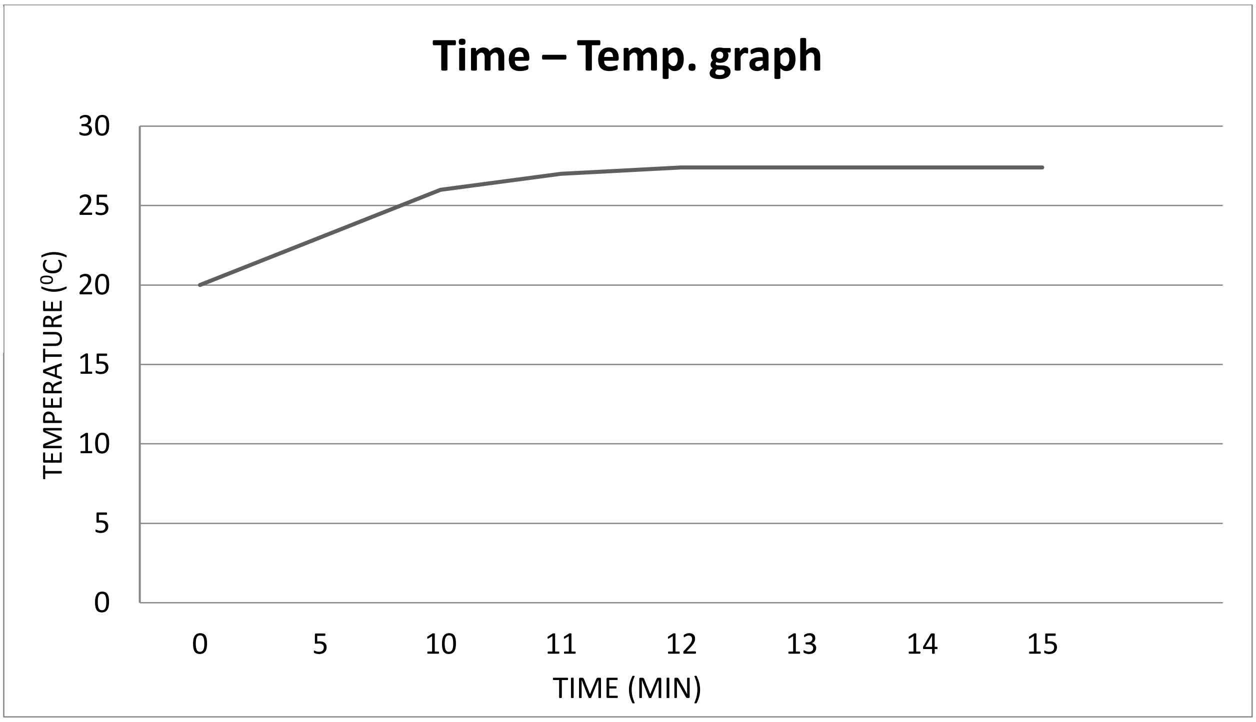


3.4. Voltage-Temperature characteristics of electro-conductive handmade carpet

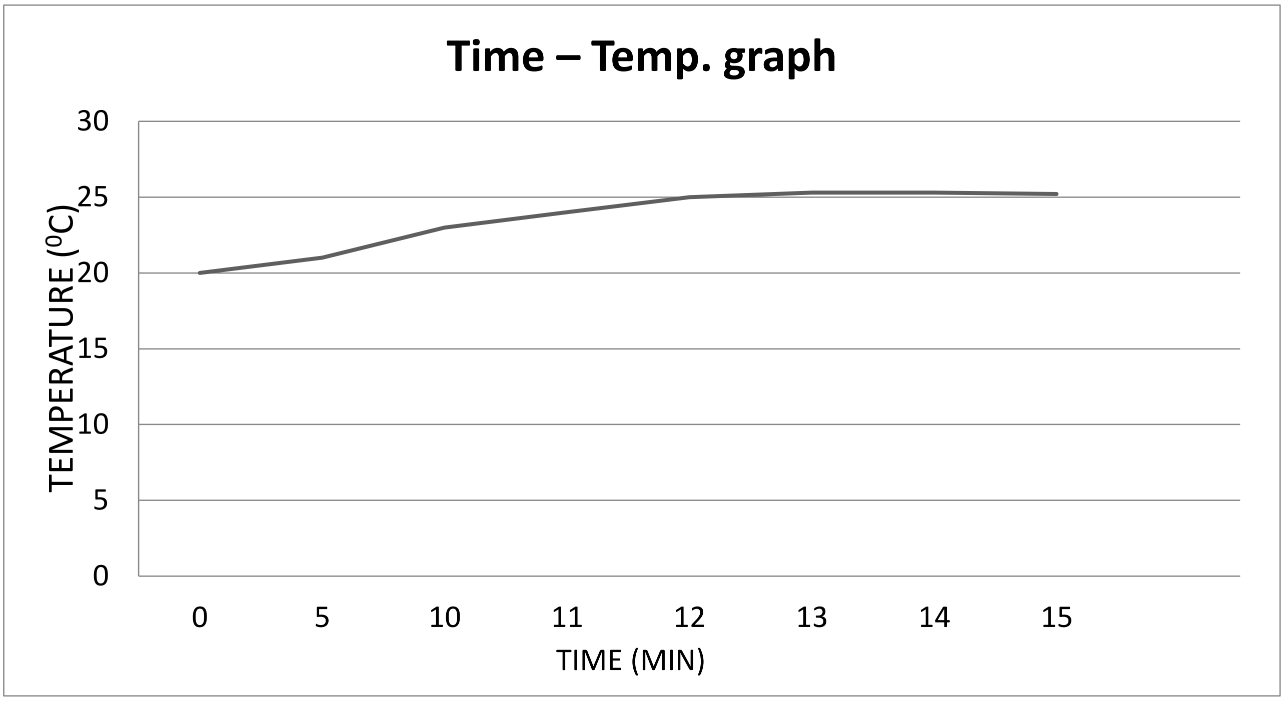
The voltage temperature characteristics of electro-conductive handmade carpet were measured at 27^{0}C and 65% relative humidity .The carpet sample (5 cm × 5 cm) was connected with power supply with help of two steel electrodes. The observed the values of surface temperature of the fabric with the help of thermometer. The voltage versus temperature curve of electro conductive carpet was obtained.



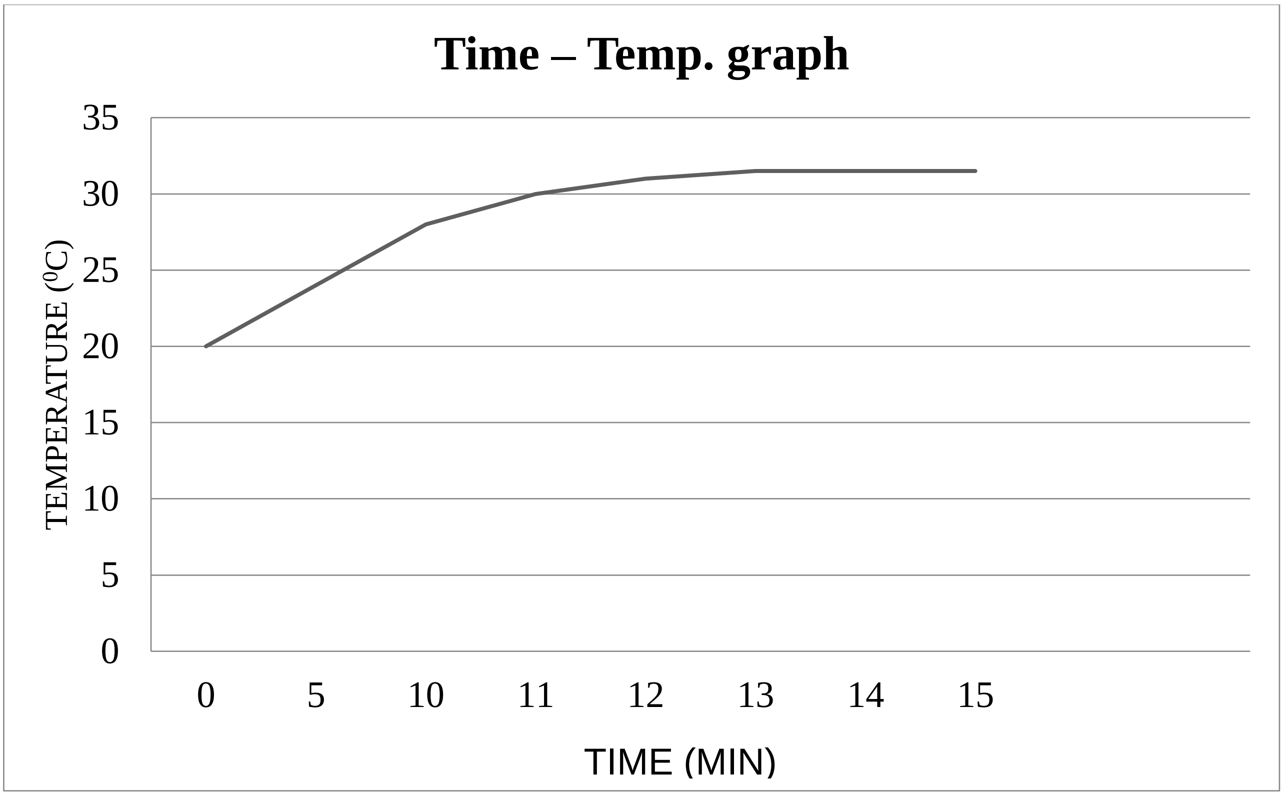
Sample – 1



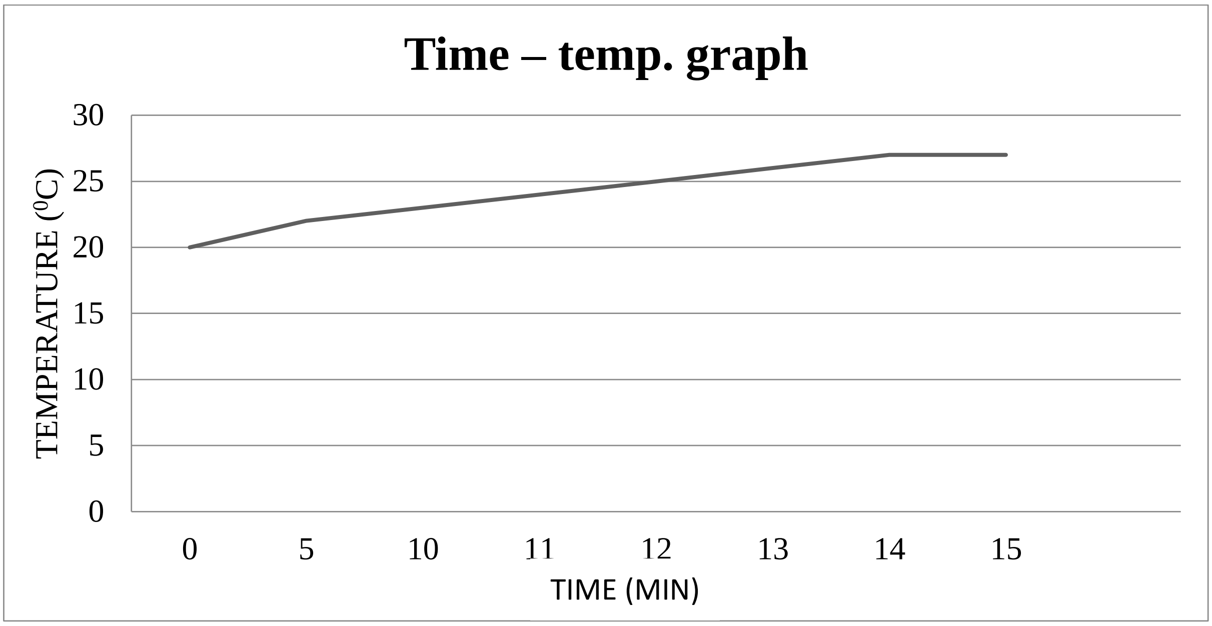
Sample–2



Sample – 3

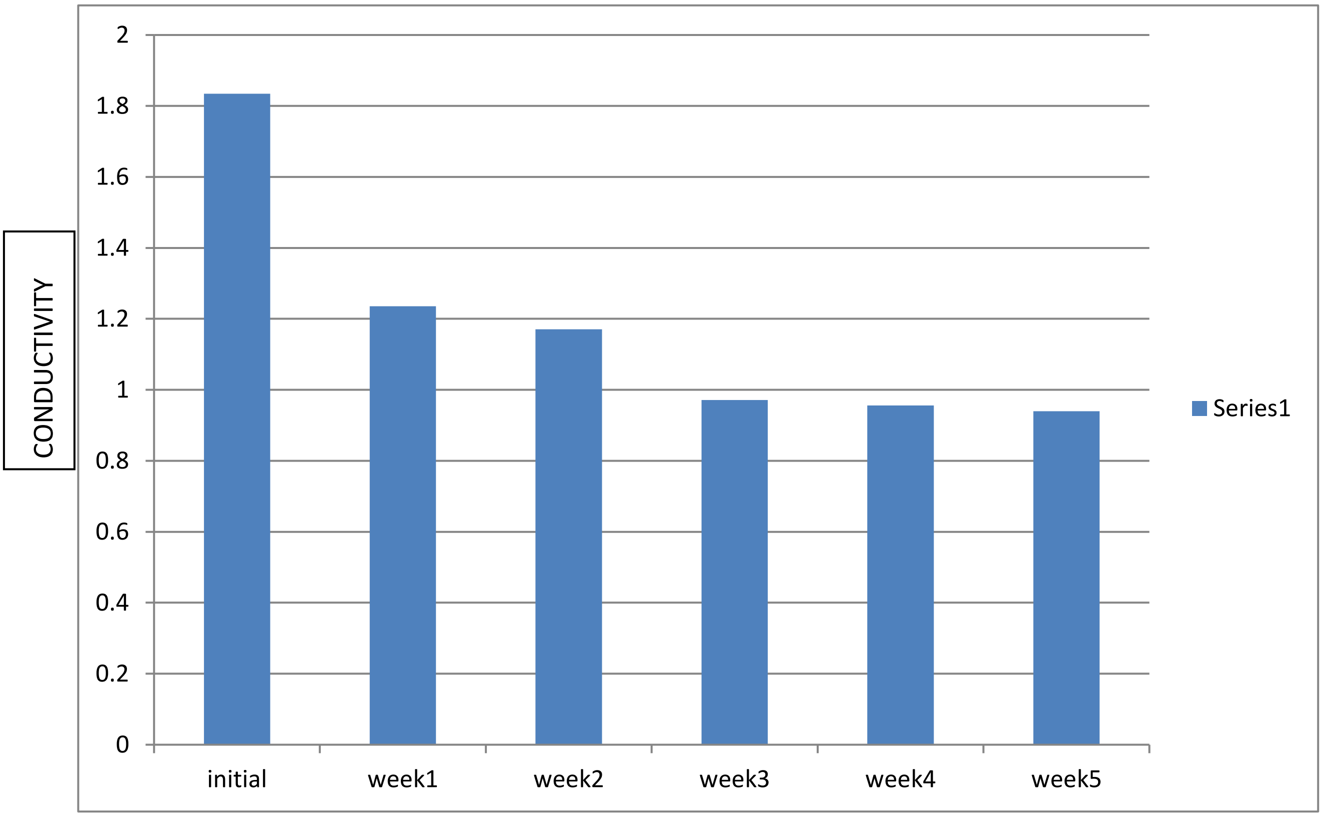


Sample – 4



3.5. Study of Atmospheric Aging

After polymerization treated handmade carpet were dried at room temperature for 24 hours. Then electrical surface resistance was measured by the method stated before. This is denoted as initial result. After 1 week, 2 weeks to 5 weeks the measurements again conducted and average values have been noted. It can be seen that as time is spending resistivity increases gradually. This is may be due to the reaction of the polymer with atmospheric oxygen. These phenomena stated the instability of the polypyrrole polymer in atmosphere.



Conductivity of the PPy coated carpet is gradually decreasing with time as shown in the graph, hence the resistivity increases correspondingly.

4. Conclusion

Conductive hand knotted carpet was successfully synthesized by in situ polymerization using pyrrole as monomer in presence of dopant. The surface resistivity, voltage-current behavior, voltage-temperature behavior and effect of time on conductivity were successfully studied of the electro-conductive handmade Carpet shows good voltage temperature behaviour i.e. when voltage is applied then due to surface resistance the carpet surface heated up and then the surroundings temperature also increases due to heating of surface. Carpet can be used as wall covering which gives the enough heat to survive in the very colder region. Carpet can also use as heating pad. The future scope of work is to improve the surface sructure by preventing the surface of carpet being black. And also the physical properties of carpet should be improved.

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