

Polymer Laboratory

Polymer Laboratory of CPRI was established during 1976 to cater to the needs of power industry in terms of Research and Development, Testing and Consultancy works. The laboratory has taken up good number of projects and completed successfully. Scale up studies have been done for development work done on Flame Retardant Low smoke PVC based cable compound and Synthesis of Novolak Resin for electrical applications. Project works have been completed which have resulted in award of doctorate and Masters degrees for several workers from different Universities. The laboratory has published several papers in International Journals besides papers presented in National seminars & conferences in addition to several product developments resulted in the form of patents. Technology development studies have been carried out for the patented product developed by involving private industry and project was sponsored by Department of Scientific and Industrial Research (DSIR) under PATSER scheme. The laboratory was also successful in conducting few consultancy studies to satisfy the requirements of electrical utilities.

1.0 INTRODUCTION

During 1976 the Polymer Laboratory was established at CPRI, Bangalore campus with the aim to develop insulation systems/materials based on Polymer compositions required for power utilities. Initially the laboratory had only 2 Engineers Viz. Mr. Veluchamy as Assistant Director along with Mr. Jayakumar who was assisting him. The officials have been asked to procure a Vacuum Impregnation Plant to impregnate paper with epoxy resin so that the material shall be used for paper insulation. The whole exercise has become unsuccessful as the type of equipment that was procured could not be installed in the laboratory due to the dimension of the equipment (height of the equipment was too high). The other attempt was to develop 11 kV PVC primary insulation material. The attempt was total failure as the basic knowledge of Chemistry of PVC resin itself was lacking among the Engineers present at that point of time. Management of CPRI has realized to appoint Chemists with good academic background to carry out research work in the area of Polymers and in this direction during 1980, Dr. N. Nandakumar who has submitted his thesis at Indian Institute

of Science, IPC Department, Bangalore, he was appointed as Asst. Director. In the year 1981, Mr. P.V. Reddy, with Chemistry Post Graduate background was appointed as Scientist Gr.3 to assist in the development of PVC for 11 kV cable applications. During 1984, Dr. R. Thiagarajan, Ph.D from IISc, IPC Department was appointed as Scientific Officer Gr.-1. At this point of time, several Research and Development works were undertaken in the laboratory. In the year 1985, Mr. S. Sridhar, M.Sc in Chemistry with a decade of experience in polymer industries has joined Polymer Laboratory as Scientific Officer Gr.-3. The presence of Sridhar has added the flavor of practical knowledge in Thermoset Resin Processing with the theoretical background of the other personnel in the laboratory.

During the year 1989, Mr. P. Sadashiva Murthy, M.Tech in Chemical Engineering and Dr. K.T. Varughese have joined the laboratory as Engg. Officer Gr.-1 and Scientific Officer Gr.-2 respectively.

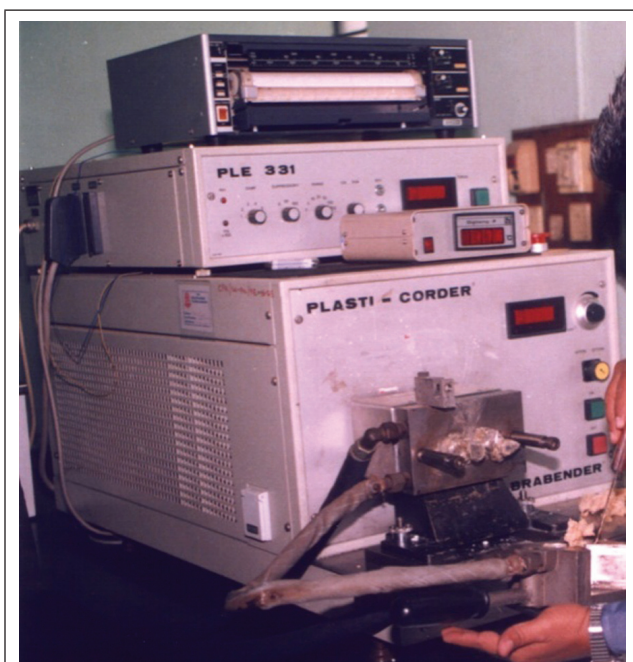
With the dynamism of Dr. M. Ramamoorthy as Director General of CPRI, several projects with thermoplastic as well as Thermoset materials

TABLE 1

Sl. No.	Name of the faculty	Duration of the stay	Qualifications	Years of experience
1	Shri B.M. Mahajan	1976–1982	AMIE	6
2	Shri Veluchamy	1976–1978	AMIE	2
3	Shri H Jayakumar	1976–1983	D.E.E	7
4	Dr. N. Nandakumar	1980–1983	M.Sc., Ph.D	3
5	Dr. P.V. Reddy	1981–2006	M.Sc., Ph.D	25
6	Dr. R. Thiagarajan	1984–1989	M.Sc., Ph.D	5
7	Shri S. Sridhar	1985–2002	M.Sc	17
8	Smt. Pavitra Gadlinge	1989–1993	M.Sc	4
9	Shri P. Sadashiva Murthy	1989–2011	M.Tech	22
10	Dr. K.T. Varughese	1989–2000 2004–2007	M.Sc., Ph.D	15
11	Mr. Sultan Mohiuddin	1976–1987	I.T.I	11
12	Mr. R. Nagaraj	1982–2011	-	29
13	Mr. T. Govindarajan	1987–	-	25

were undertaken which has helped in the growth of the laboratory in the area of Research, Development, Testing and Scale up studies. This had greater impact on the growth of the laboratory in academic excellence.

The Technical personnel have worked and contributed to the technical growth of the laboratory. The details are given in the Table 1.



PROCESSING EQUIPMENT-PLASTIC ORDER

During the initial stages, the polymer laboratory was attached to Insulation Division headed by a Senior Deputy Director (Shri B. Mahajan). During 1990's the laboratory was attached to Dielectric Materials Division headed by a Joint Director.

During early 1980's very few equipment's like Compression molding-machine, Injection-molding-machine, Rockwell Hardness Epoxy mixing plant, Vacuum impregnation plant, PVC compounding unit with pelletizer and granulator were procured/made available under UNDP programme. Initially the basic impregnation of paper with epoxy resin studies was carried out intending to use as Electrical insulation.

The first recognized Research project that was initiated in the laboratory was in the year 1981–1982 to develop 11 kV PVC primary insulation for cable applications. When the laboratory studies were successful, scale up studies were undertaken at a Cable industry viz. M/s. Industrial Cables India Ltd, Rajpura, Punjab.

The R&D activities were enhanced after 1984 with more number of technical personnel made available in the laboratory.



COMPRESSION MOULDING MACHINE

2.0 RECOGNITION BY BANGALORE UNIVERSITY

During the year 1986–1987, sincere efforts were made and the laboratory was recognized by Bangalore University for carrying out Research work based on the registration application submitted by the laboratory. Based on the investigation studies carried out and the data generated on the project ‘Studies on the use of Transition Metal Chelates as accelerators for curing of Epoxy Resin Systems’, a thesis was submitted during 1991 to Bangalore University and Ph.D degree was awarded to Mr. P.V. Reddy in the year 1992.

3.0 EQUIPMENTS

With the increase in demand for thermal characterization and also for processing of Polymers during 1985–1986, thermal and processing equipment's like Thermo Gravimetric Analyzer, Differential Thermal

Analyzer, Differential Scanning Calorimeter, Gel Timalong with Brabender Plasticorder (processing unit) were procured. These equipments were useful for evaluation of properties like Decomposition Temperature, Glass Transition Temperature, Thermal Rating Evaluation of Insulating Systems and other thermal properties.

During 1990–2005, several sophisticated instruments like Fourier Transform Infra Red Spectro Photometer, Thermo Mechanical Analyzer, Mooney Viscometer, Rubber Curing Rheometer were procured and installed in the laboratory for spectral and cure studies. These facilities were more useful for Rubber based investigations taken up in the laboratory including the programme on development of Polymeric insulators for outdoor applications.



THERMO MECHANICAL ANALYSER

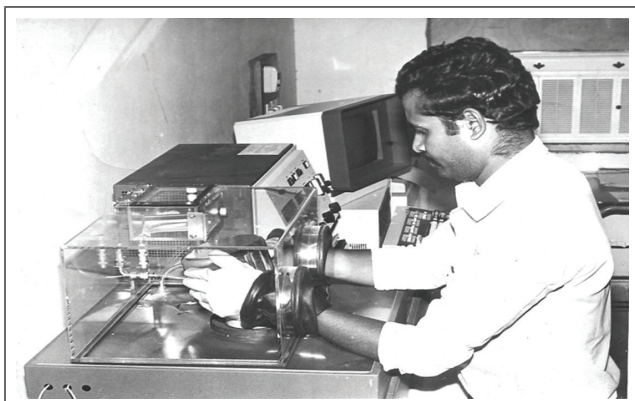
A large number of University Colleges, Processing Industries, and Manufacturing units all over the Country have benefitted from the expertise and the facilities available at polymer Laboratory. The activity has resulted both in terms of revenue generation and growth of Science and Technology in Electrical Industry as polymer based insulating materials.

4.0 RESEARCH PROGRAMMES

The Research programmes under taken and completed over a period of time during 1981

and 2006 are listed below:

- (a) Development of 11 kV primary insulation for power cables
- (b) Reclamation of Scrap XLPE
- (c) Flame retardant PVC compound for power cables
- (d) Thermal life evaluation of Magnet Wire Enamels
- (e) Resin for Dry type transformers
- (f) Development of Anti oxidants for Polyolefins
- (g) Development of Epoxy Novolak resin for electrical applications
- (h) Investigations on polybenzimidazoles for electrical applications
- (i) High temperature thermoset materials for electrical applications (a sponsored project from Central Board of Irrigation and Power, New Delhi)
- (j) Studies on the use of transition metal chelates as accelerators for curing of epoxy resin system
- (k) PVC-rubber blends for FRLS applications
- (l) Development of Polymer concrete insulators for HV applications
- (m) Low cost resins from CMVP – P2 and P3 applications
- (n) Development of Semicon compounds for Cable applications



DIFFERENTIAL SCANNING CALORIMETER

- (o) Improved EN – by making LV EN for casting applications
- (p) Technology development of FRLS compound for cables



PVC COMPOUNDING UNIT

5.0 QUALITY DEVELOPMENT OF HUMAN RESOURCE

Polymer laboratory has been supporting Research activities of other divisions like HV, DCCD, MTD, Insulation Laboratory, etc., by using analytical facilities such as TGA, DSC, DTA and FTIR. Similarly, other academic and research organizations have benefited in generating high quality research output using facility of this laboratory. The Scientists of this laboratory have guided Ph.D, M.Tech and B.Tech project works and contributed to the high quality development of Human Resource. The details are given in the Table 2.

6.0 CONSULTANCY WORKS

The following Consultancy works have been undertaken at this laboratory and successfully completed.

1. Technical clarifications of Electromechanical Energy Meters to M/s. Eastern Power Distribution Company Limited of Andhra Pradesh, during December 2003, By Dr. P.V. Reddy

TABLE 2				
LIST OF PROJECT WORKS GUIDED BY POLYMER LABORATORY				
	Name of the candidate, Shri/Smt/ Kum	Degree	University/College	Status
1)	Sakunthala Samuelson	Ph.D	Bangalore	Completed (2009)
2)	R. Prakash Kumar	Ph.D	Bangalore	Completed (2006)
3)	B.R. Manjunath	Ph.D	Kannur, Kerala	Completed (2005)
4)	H.N. Chandrakala	Ph.D	VTU, Karnataka	Completed (2006)
6)	K. Praveen	M.Tech	NITK, Surathkal	Completed (2005)
7)	Amitha S Gowda	M.Tech	NITK, Surathkal	Completed (2006)
8)	S. Nalina	M.Phil	Periyar University, Tamilnadu	Completed (2009)
9)	Amitha S Gowda	B.Tech	SJCE, Mysore, VTU	Completed (2004)
10)	K. Praveen	B.Tech	SJCE, Mysore, VTU	Completed (2003)
11)	R. Ramachandra M. Ilyas N. Shyla H. Bhagya G Bhargavi	B.Tech	SIT, Tumkur, VTU, Belgaum	Completed (2001)
12)	K.G.Ajeev S. Girikrishnan	B.Tech	Univ. College of Eng., Thodupuza, Kerala	Completed (2001)
13)	H. Sunitha N. Surekha K.P. Priya R. Aruna	B.Tech	MVJCE, VTU, Belgaum	Completed (2000)
14)	L. Roopa H. Shobha C.B. Srividya	B.Tech	SIT, Tumkur, VTU, Karnataka	Completed (1999)

2. Feasibility Study of using Battery Separator grade resin for insulation applications, referred by office of the Commissioner of Central Excise, C.R. Building, I.P. Estate, New Delhi.

Based on the study it was suggested as the following:

- When Battery separator resin CP172 SG added to K6701, the elongation property decreases with increase in its content i.e, the material attains rigidity suggesting that CP172SG is not a good absorbent of plasticizer.
- It has been confirmed that the particle sizes of these 2 resins are not the same and a just physical mixing need

not be a homogeneous mixture and this could affect the properties of the compounded material intended to use for HT cable.

- The samples CP 172 SG and K6701 both may be used for LT PVC cable sheathing and CP 172 SG cannot be used in XLPE (cross linked polyethylene) LT cables. However, only sample K6701 can be used for insulation.

The study has helped M/s. Central Excise department to recover huge amount of money due from the default industries as tax.

The Study was conducted by Dr. P.V. Reddy and the report was submitted to

M/s. Central Excise, New Delhi, during August 2007.

3. Research work to study the Failure analysis of the potential Transformers used by M/s. Delhi Metro Rail Corporation Ltd, Delhi.

There have been a large number of failure cases of potential transformers that are being used at various stations of M/s. DMRC. The Train Depot, Shastri Park, Delhi of M/s. DMRC has sought the assistance of CPRI to study the failed PT of AB 249 of Chawri Bazar Metro station and to establish the process parameters and evaluation of the material for potential transformers.



GLASS GRINDING UNIT

The study suggested that the thermal properties for the solid resin system of M/s. Pragati Electricals were slightly lower as compared to the literature values. The partial discharge test carried out on the 33 kV Power Transformer has indicated a value > 50 pC which is beyond the limit specified in IS. However the Lightning Impulse and Power frequency voltage withstand tests were in accordance with the requirements of BIS. A suitable recommendation has been made based on the study conducted.

The study was conducted by Dr. P.V. Reddy and the report was submitted to M/s. Delhi Metro during November 2009.

7.0 TECHNOLOGY DEVELOPMENT AND SCALE UP STUDIES

On completion of some of the laboratory investigations few scale up studies were undertaken and detailed studies were made on the following topics.

- (a) Technology development of flame retardant low smoke cable insulation and sheathing applications under PATSER scheme of Department of Scientific and Industrial Research, New Delhi was undertaken with the assistance of a local private factory (M/s. Farcom Cable Systems Pvt. Ltd, Bangalore). The development of sulphate glass was a notable achievement which reduces the smoke generation during the combustion of the PVC cable material under fire conditions.

The result has generated serious interest to Industry and DST as a useful technology development.

The Highlight of the achievements in this work is as follows:

- (i) Development of Low Smoke Flame Retardant Cable and Compound.
 - (ii) Attempt to eliminate the toxic chemicals in the formulation of the compound.
 - (iii) Extrusion trials using twin screw extruder and cable coating with single screw extruder was successful.
- (b) Epoxy Novolac Pilot plant was set up to prepare higher quantities of Epoxy Novolac Resin from waste product of Coal tar distillate which contains Multi Valant Phenol (MVP). High Voltage Insulators were made and tested for Indoor applications up to 11 kV rating.

8.0 PATENTS OF THE POLYMER LABORATORY

Based on the investigations/studies conducted in the laboratory the details of Patents obtained and under process with the patent office are given

below:

- (a) An Indian Patent (181043) on the development of 'Epoxy resin system comprising of latent accelerator based on transition Metal Chelates by P.V. Reddy.
- (b) An Indian Patent (201478) on the 'Development of Flame retardant Low Smoke Compound based on PVC for Cable applications by P.V. Reddy.
- (c) An Indian patent (234791) on 'A flame retardant Composition for cable applications' has been obtained by P.V. Reddy.
- (d) Patent(366/CHE/2005) on "PVC based FRLS material using sulphate glass composition for cable insulation and sheathing applications" has been filed during March 2005 with M/s. Davar & Co. Calcutta by P.V. Reddy and D. Jaichand.
- (e) Patent (209/CHE/2006 Dt.8/2/2006) on "Compositions for Polymeric High-Voltage insulators for outdoor applications" is being made for submission to M/s. Davar & Co. Calcutta by P.V. Reddy, N. Vasudev and K. Dwarakanath.
- (f) Patent(1896/CHE/2006) on "Nitrogen heterocycle as an accelerator for curing of Epoxy resin system" has been filed during October 2006 with M/s. Davar & Co, Calcutta by P.V. Reddy.

The laboratory has contributed about 13 Technical reports, 15 International journal papers and more than 25 National papers in the field of polymers for electrical applications. The list of papers published in Journals is given in the bibliography.

9.0 CONCLUSION

During the last three decades Polymer Laboratory at CPRI has assisted the electrical utilities for their growth in terms of product evaluation, development of new flame retardant low smoke cable compounds, curing accelerators for epoxy resin systems etc. The volume of Testing also has grown up over a period of time with good

number of publications from the findings of the work carried out.

ACKNOWLEDGMENT

This paper has been prepared by Dr. P.V. Reddy, presently working as Joint Director (Training Division), CPRI, Bangalore.

The author would like to place on record the significant contribution made by Dr. N. Nanda Kumar, presently working as Technical Director at M/s. Sankhla Industries, Bangalore, Late Dr. R. Thiagarajan, Mr. S. Sridhar, Retired Additional Director, CPRI, Bangalore, Mr. P. Sadashiva Murthy, Engineering Officer Gr.-4, presently working at Regional Testing laboratory, CPRI, Noida and Dr. K.T. Varughese, Joint Director. Mrs. Pavithra Gadlige also worked at Polymer Laboratory for a short duration and transferred to Thermal Research Centre, CPRI, Nagpur.

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