# A Survey On Bio-Based Materials for Printed Circuit Boards

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## Abstract

This paper reviews the use of biobased materials derived from renewable feedstock for use in Printed Circuit board (PCB) laminates. It also emphasis on material selection for PCB and the need to look for alternatives to petroleum based materials. Survey shows that biobased materials with good performance criteria and low environmental impact can be successful substituents for petroleum based materials if they are optimized to Institute of Printed Circuits(IPC) specifications.
**Keywords: Biobased materials, Printed Circuit Boards, Institute of Printed Circuit Boards (IPC)**

## I. INTRODUCTION

Printed Circuit Boards –PCB is the heart of most electronic products from mobile phones to control systems for satellite earth stations (1,2).The world wide requirement of PCB is projected to reach $76.2 billion by 2015(2). Most PCBs used today are derived from petroleum based sources. Conventional PCB laminates are based on FR4, high temperature FR4, polamides , cyanate esters, bakelites and ceramics with glass fibers as reinforcements(3).Flame retardants include halogenated compounds like polybrominated biphenyls, polybrominated diphenyls ethers and non-halogenated compounds like aluminium trioxide, magnesium hydroxide, phosphate esters and melamine derivatives.(4) Many of these materials pose serious threat to health and environment during manufacturing, incineration and recycling. Risks are related to emission of toxic gases such as furan, dioxins and green house gases with high CO2 footprint. Europe's Restriction of Hazardous Substances (RoHS), European End of Life Vehicles (ELV) and Waste from Electrical and Electronic Equipment Directives (WEEE) have laid stringent regulations on the use of hazardous substances in electronic products(5-7).

Increasing environmental awareness, globally increasing crude oil prices, e-waste disposal and recycling problems, high processing cost and World wide environmental legislations has urged researches to look for new alternatives with good performance criteria and low environmental impact for use as substitutes(8). This lead to the introduction of biobased materials in electronic industry .Bio-based material derived from renewable feedstock are more biodegradable, less economical, have less CO2 footprint and hence are ecofriendly with good environmental acceptability(9-17). Literature shows the use of biobased resins and natural plant fibers in electronic industry. This paper is a review on the use of biobased materials in PCB laminate manufacturing.

## II. MATERIAL SELECTION TO DESIGN PCB

A material selected for use in PCB must be tested according to standards and test methods developed by the Institute of Printed Circuits (IPC).

PCB material selection should be specific based on the mode of application. When specifying materials requirements such as temperature (soldering and operating), maximum end use temperature, electrical properties, interconnections (soldered components, connectors), structural strength, and circuit density must be considered. Other factors include: Resin Formula, Flame Resistance, Thermal Stability, Structural Strength, Electrical Properties, Flexural Strength, Maximum Continuous Safe Operating Temperature, Glass Transition Temperature (Tg), Reinforcing Sheet Material, Nonstandard Sizes and Tolerances, Machinability or Punchability, Coefficients of Thermal Expansion (CTE), Dimensional Stability, and Overall Thickness Tolerances. In terms of electrical properties, dielectric constant, moisture resistance, and hydrolytic stability must be considered(18-19).

Certain requirements according to IPC 4010A/24 for FR4 PCB are presented in the table 1(22).

TABLE - 1
Requirements according to IPC 4010A/24 for FR4 PCB(22)

| *Sl.No* | *Laminate property* | *Requirement* |
|---|---|---|
| *1* | *Peel strength, minimum* | *1.05* |
| *2* | *Volume resistivity, minimum* | *103-104* |
| *3* | *Surface resistivity, minimum* | *103-104* |
| *4* | *Dielectric breakdown, minimum* | *40* |

| | | |
|---|---|---|
| *5* | *Permitivity at 1 MHz, maximum* | *5.4* |
| *6* | *Loss tangent at 1 MHz, maximum* | *0.034* |
| | *Fill flexural strength, minimum* | *3.45* |
| *7* | *Warp flexural strength, minimum* | *3.45* |
| *8* | *Arc resistance, minimum* | *60* |
| *9* | *Thermal stress 10s at $288^0$C, minimum* | *Pass visual* |
| *10* | *Flammabiility, minimum* | *V-1* |
| *11* | *Glass transition temperature, minimum* | *150* |
| *12* | *Moisture absorption* | *0.8* |

If the material satisfies the IPC requirements they can be opted for use as PCB laminates.

## III. LITERATURE

Literature studies shows that bio based materials can be used to create PCBs with acceptable performance and low environmental impact.

Wool et al developed new bio-based composites from acrylated epoxidised soyabean oil, halogen-free flame retardants and chicken feather fibers for printed circuit applications.Divinylbenzene (DVB) or chemically modified by phthalic anhydride were used as cross-linking agents. The DVB-crosslinked resins had a 14–24°C increase in their glass-transition temperatures (Tg′s), which was dependent on the crosslink densities. Tg increased linearly as the crosslink density increased. Phthalated acrylated epoxidized soybean oil (PAESO) had an 18–30% improvement in the modulus. The dielectric constants and loss tangents of both DVB-crosslinked AESO and PAESO were lower than conventional dielectrics used for PCBs. The resulting boards were tested for qualities including rigidity and wetting (the fibers must be saturated by the soybean resin to achieve the desired dielectric constant), as well as vibration damping and thermal expansion These results suggest that the new biobased resins with lower carbon dioxide footprint are potential replacements for commercial petroleum-based dielectric materials for PCBs.(20-21)

John .D.Lincoln et al have developed bio epoxy-flax composites prototypes for use in PCBs. Both treated and untreated flax fibers were used with melamine polyphosphate (MPP) as flame retardant and the epoxy resin was prepared from linseed oil. The treated-fiber PCB design satisfied most of the characteristics necessary for proper performance, including flammability, thermal resistance, mechanical performance, and most electrical properties. In the analysis according to IPC, of 18 key performance conditions, 15 requirements are meet, while three do not. All three failing properties were within a close margin of the required values. With additional test and development work the composite can be made ready for use in future. (22-23)

Kosbar and Gelorma developed PCB prototype laminates by incorporating lignin into epoxy matrix. Flame retardance was achieved using the traditional approach of brominated epoxy resins and antimony oxide. The test boards were tested as per IPC specifications. Results suggest that performance meet most requirements and specifications in all categories and moisture absorption did not pose a problem since fiber glass was used as reinforcement. They also performed a life cycle assessment (LCA) to compare the standard epoxy to the lignin-modified epoxy. Their analysis indicates a reduction of up to 40% in energy consumption for the bio-based resin. Their design requires no significant alteration of present processes or equipment, and its cost is lower than the cost of present systems, their design is readily adoptable into the PCB manufacturing industry (24).

Nagele et al. (25) developed PCB laminates from biobased thermoplastic Arboform with chopped hemp and wood fiber as laminates. The matrix of Arboform material is comprised of lignin polymers, a by-product of paper pulping. Moisture absorption was not specifically examined, but would likely have been a problematic property considering the nature of the reinforcement. They concluded specific properties must be examined and optimized in order to ensure their acceptance by the electronics industry.

## IV. CONCLUSION

Currently there is no legislations restricting the use of petroleum based resin and synthetic fibers in PCB. “The chief factor in any new development in PCB industry will depend be cost, the green aspects, and the electrical and mechanical properties Circuit board industry is endeavoring to progress in a “green” direction on several fronts, including moving away from lead solders and developing halogen-free laminates. Another step forward is the use of renewable biobased resin and natural fibers in PCB manufacturing. Literature shows that biobased materials can be successful competent for conventional petroleum based materials inspite of the fact that their properties should be optimized to meet IPC specifications. If biocomposites prepared meet specific requirements like cost and other performance criteria they can successfully replaced for conventional PCBs.

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