ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)
Vol 2, Issue 12, December 2017

Synthesis and characterization of cardanol-formaldehyde resins

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***Abstract:*-- This study presents the synthesis of cardanol-formaldehyde resins from cardanol. Cardanol-formaldehyde resins were synthesized by condensing cardanol with formaldehyde using malonic acid as catalyst. The resins were characterized by physico-chemical and spectral studies such as NMR and FT-IR. It shows that cardanol-formaldehyde resin possess higher specific gravity and viscosity due to higher degree of condensation between cardanol and formaldehyde.**

Keywords: **Cardanol; formaldehyde; malonic acid; spectral studies.**

I. INTRODUCTION

Cashew nut shell liquid (CNSL), a renewable resource material obtained as a byproduct of the cashew industry[1]. Major fraction of CNSL is cardanol which is meta-substituted and unique in that it contains a phenolic moiety with an unsaturated 15-carbon side chain[2]. Phenol-formaldehyde was mixed with cardanol-formaldehyde to obtain cardanol-phenol-formaldehyde resin, which is used as a binder for friction material. The phenolic nature of the material makes it possible to react under a variety of conditions to form both base catalysed resins and acid catalyzed resins[3-5]. Resins based on phenol-formaldehyde, cardanol-formaldehyde, phenol-furfural[6] molar ratios with different dicarboxylic acid catalysts such as adipic acid, sebacic acid, oxalic acid and succinic acid and tricarboxylic acid catalyst, namely, citric acid. The prepared resin system finds numerous applications in composite matrix, surface coatings, lamination industry, pesticides, etc[7-11].

2. EXPERIMENTAL

2.1 Materials

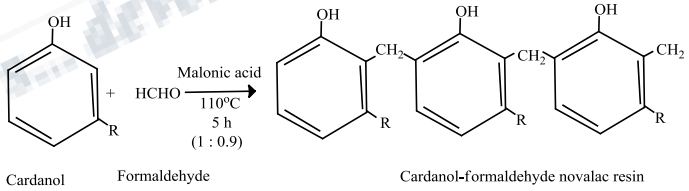
Cardanol was obtained from M/s Satya Cashew Chemicals Pvt. Ltd., Chennai. Formaldehyde (40% solution), and malonic acid and methanol were received from Merck, Mumbai.

2.2 Methods

^{1}H-NMR spectra are recorded in CDCl3 with tetramethylsilane as an internal standard. The spectrum was recorded using Brucker Avance H 500 MHz spectrometer. Infrared spectra of the polyurethane and its composites were taken in a Shimadzu FT-IR-8400S spectrometer by KBr pellet method.

2.3 Synthesis of cardanol-formaldehyde resins

Cardanol-formaldehyde (novalac) resins were synthesized by the condensation of cardanol and formaldehyde using malonic acid as catalyst (Scheme 1). Cardanol was taken in a three necked flask equipped with a Liebig condenser, mechanical stirrer and thermometer. Formaldehyde and 1% malonic acid catalyst in methanol was added to the cardanol through a dropping funnel. The reaction was carried out at temperature 110o ± 5oC for 5 h. The resins were precipitated in distilled water and purified by dissolving in ether. The resins were characterized by physico-chemical properties, nmr and infrared spectral studies.



Scheme 1
Formation of cardanol-formaldehyde resin

3. RESULTS AND DISCUSSION

The cardanol-formaldehyde resin possess higher specific gravity and viscosity due to higher degree of condensation between cardanol and formaldehyde. The low iodine value in comparison with that of cardanol may be due to steric hindrance of adjacent bulky groups to the olefinic addition of iodine monochloride during the estimation of iodine value. The physico-chemical properties of the cardanol and cardanol-formaldehyde resin has been shown in Table 1.

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Table 1
Physico-chemical properties

Properties	Cardanol	Cardanol-formaldehyde resin
Colour	Dark brown	Reddish brown
Odour	Phenolic	Phenolic
Specific gravity (g/cc at 30°C)	0.9312	0.9438
Viscosity at 30°C (cps)	159	230
Iodine value (Wij's method)	221	216
Hydroxyl value	183	168
Molecular weight	302	1172
Number of hydroxyl groups	1	3
Moisture content (%)	0.894	0.921

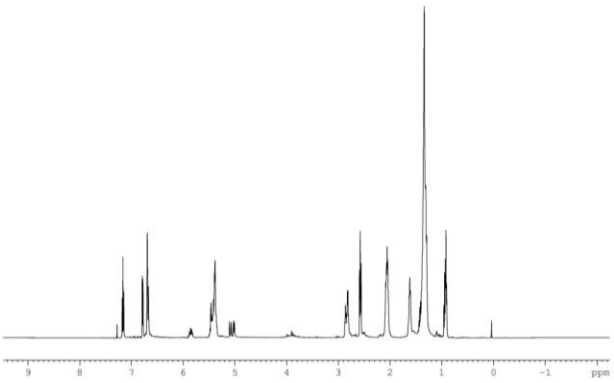

Fig 1
^{1}H-NMR spectrum of cardanol-formaldehyde resin

^{1}H-NMR spectra of the resin (Fig 1), showed the small peak at 0.89 δ and the strong peak at 1.30 δ indicates the presence of terminal methyl group of the chain and the long chain (more than five methylene groups) of the side chain respectively. The peaks around 1.551 δ and 2.876 δ are due to aliphatic side chain of cardanol. The peaks at 6.651 δ - 7.276 δ are due to the aryl protons of benzene nuclei.

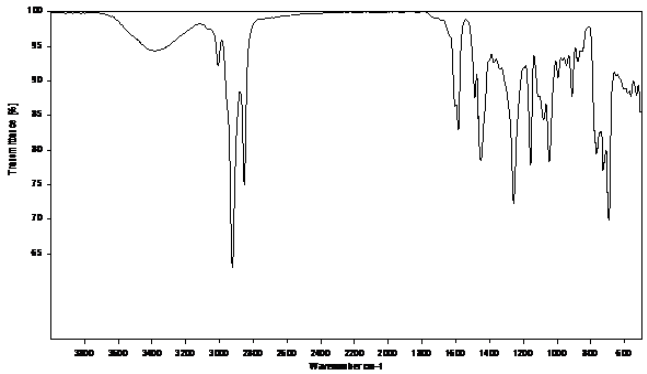

Fig 2
FT-IR spectrum of cardanol-formaldehyde resin

FT-IR spectra of the resin (Fig 2) exhibit phenolic hydroxyl peak at 3400-3300 cm^{-1}. The peaks around at 3009 cm^{-1} and 2924 cm^{-1} might be due to the aromatic -CH stretching and aliphatic -CH stretching respectively. The peak at 912 cm^{-1} is due to substitution in benzene nuclei and the peaks at 779 cm^{-1} and 693 cm^{-1} are due to three adjacent hydrogen atoms in the benzene nuclei. A peak at 720 cm^{-1} reveals the presence of ortho substitution at benzene nuclei.

4. CONCLUSIONS

The cardanol-formaldehyde resin possess higher specific gravity and viscosity due to higher degree of condensation between cardanol and formaldehyde. The low iodine value in comparison with that of cardanol may be due to steric hindrance of adjacent bulky groups to the olefinic addition of iodine monochloride during the estimation of iodine value. These analyses indicate that resin showing ortho linkage.

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