Supporting Information

Synthesis and Performance Evaluation of Castor Oil-Styrene Co-Polymer: An Outstanding Multipurpose Directional Lubricant Additive

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Spectroscopic measurements:

FT - IR and NMR techniques were used to characterize the polymers' and composites' spectrum properties. IR spectra in the 400 – 4000 cm^{-1} wave number region were captured using 0.1 mm KBr cells at room temperature on a Shimadzu FT-IR 8300 spectrometer. Using a 5 mm BBO probe and $CDCl_3$ solvent, NMR spectra were captured utilizing a Bruker Advance NEO 400 MHz FT-NMR spectrometer. TMS was employed as a source of standard information.

Analysis of the Spectroscopic Data:

The analysis of spectroscopic data for the prepared polymers confirmed the predicted structure of the additives. For copolymers, the presence of the ester carbonyl group of castor oil was verified by the characteristic IR absorption peak at 1743 cm^{-1}. Additionally, peaks in the range of 2857-2931 cm^{-1} indicated the presence of other components. The peaks at 695 cm^{-1},724 cm^{-1}, 756 cm^{-1}, and 810 cm^{-1}were indicative of the aromatic part of styrene (Figure 1).

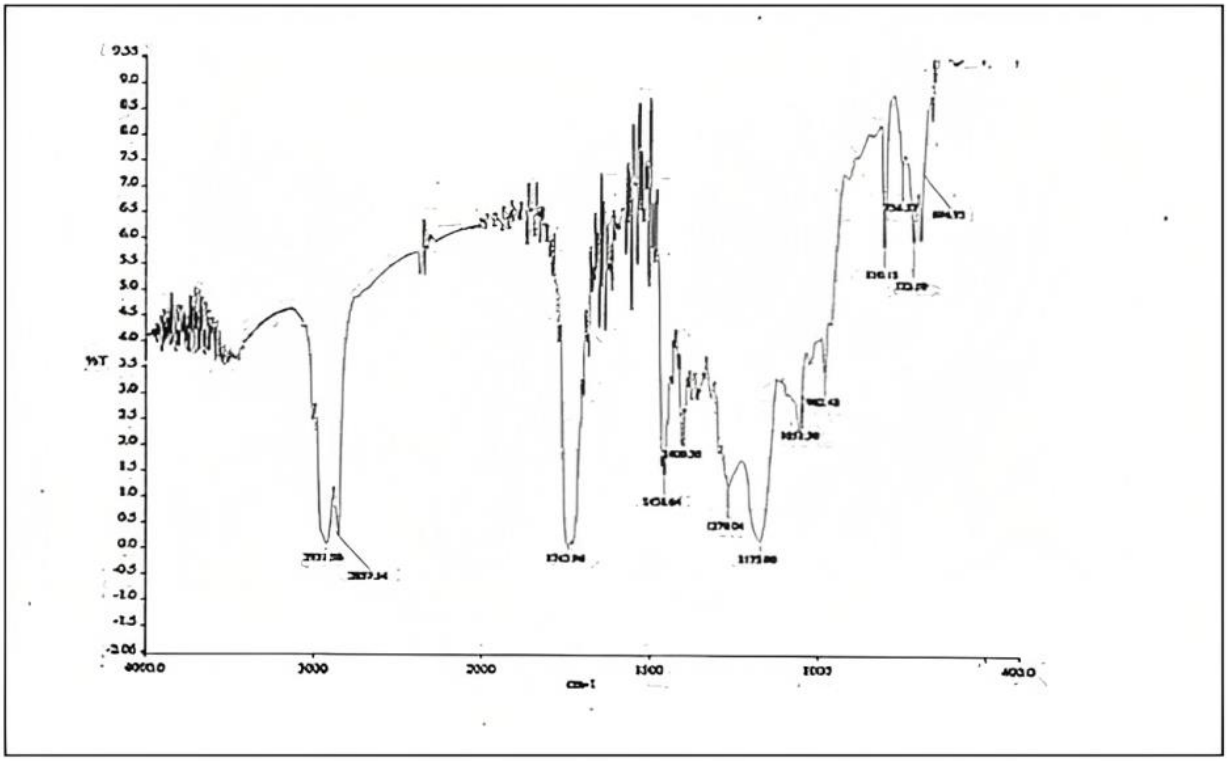

Figure S1: FT-IR spectroscopic image for the copolymer of Styrene-Castor oil

The ^1H NMR spectra analysis revealed specific chemical shift ranges corresponding to different proton groups in the polymers. Protons in the methyl group were observed between 0.88 - 0.90 ppm. Protons in the methylene group were assigned peaks ranging from 1.28 - 1.63 ppm. The methine protons were observed within 2.04 - 2.30 ppm. The proton associated with $-OCH_2$ group appeared at 4.08 ppm. Protons from the $-COOCH_2$ group of castor oil peaks are represented by the peaks in the range of 4.10 - 4.15 ppm. The aromatic ring protons of styrene exhibited a broad peak spanning from 6.80 - 7.64 ppm (**Figure 2**).

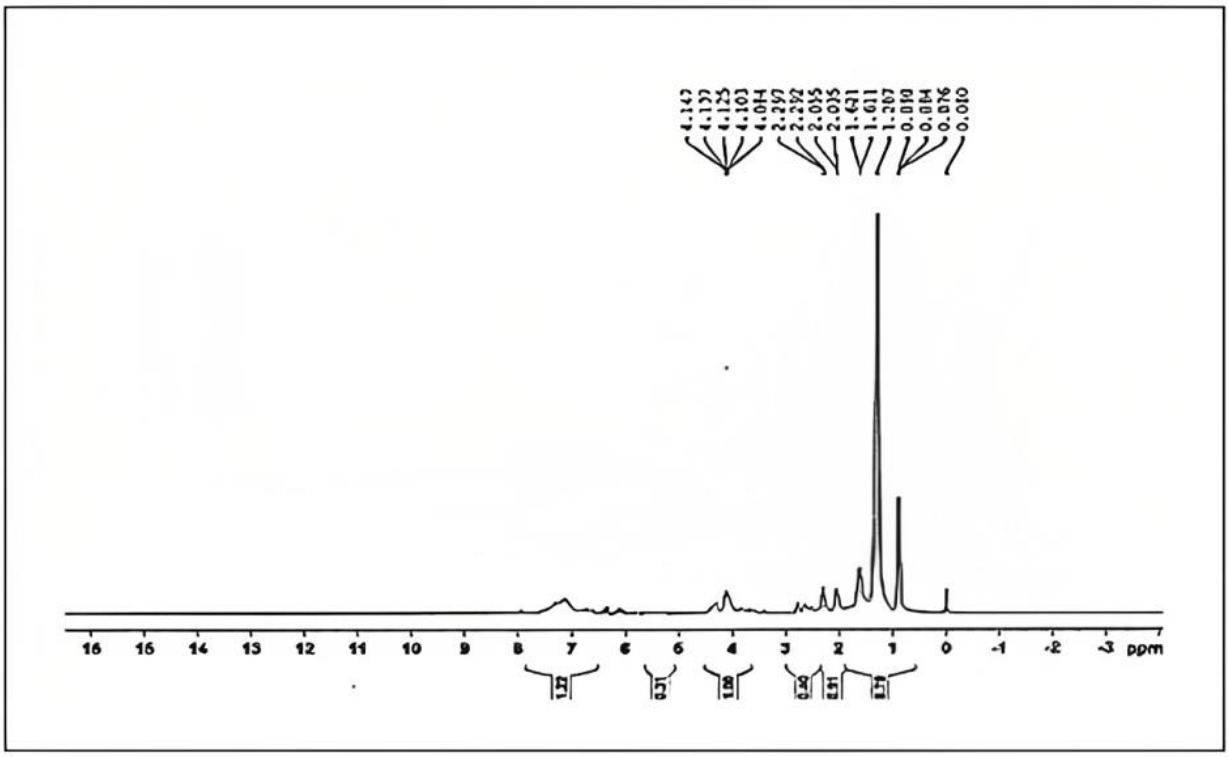

Figure S2: ^{1}H NMR spectroscopic image for the copolymer of Styrene - Castor oil

In the ^{13}C NMR spectra, different carbon groups in the copolymer exhibited specific chemical shift ranges, allowing for their identification. Carbon atoms in the CH_3 and CH_2 groups appeared within the range of 14.1 - 41.0 ppm. Peaks at 58.1 ppm testify the existence of methine carbons in the -CH- of the -COCH group. Peaks ranging from 60.0 to 62.1 ppm and 64.6 - 68.9 ppm represents carbon atoms in the -OCH_2 groups and -CH_2 carbons in the -$OCOCH_2$- group respectively. The peaks in the range of 127.9 - 130.8 ppm and 165.6 - 173.0 ppm represent the aromatic carbons and ester carbonyl carbon (**Figure 3**).

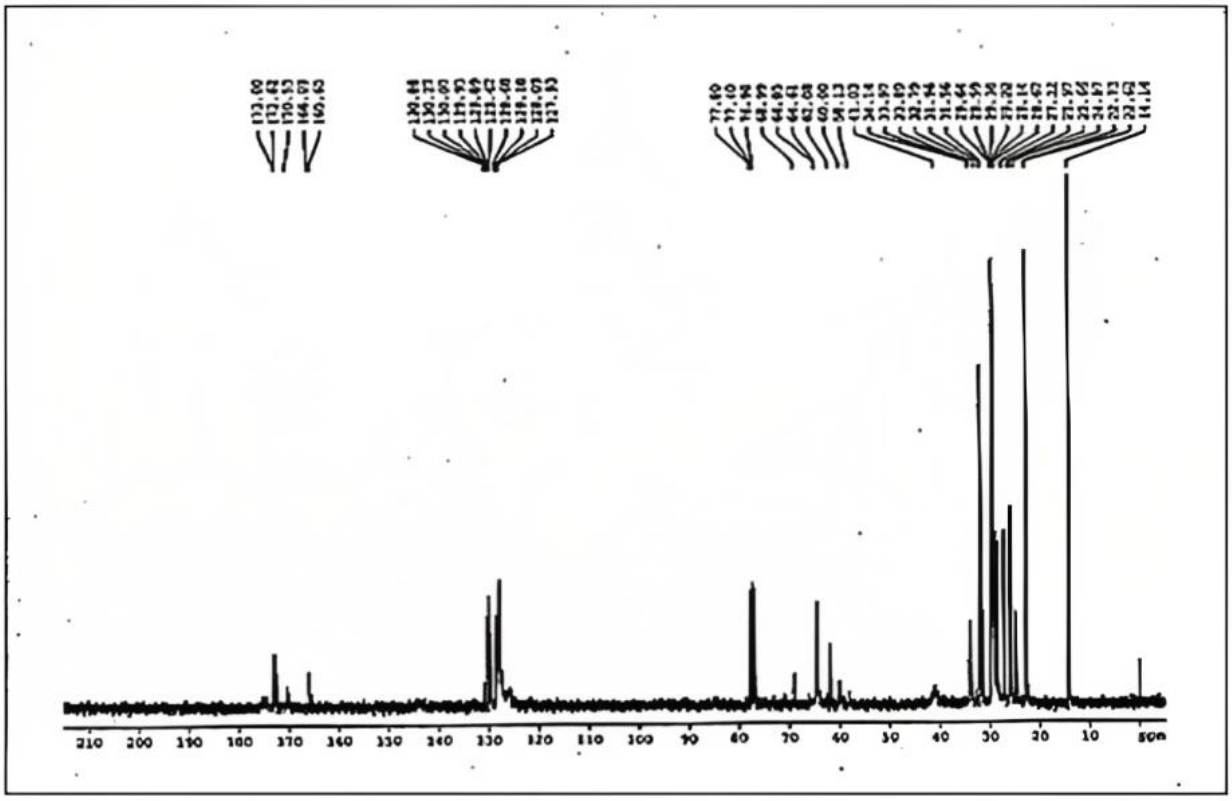

Figure S3: ^{13}C NMR spectroscopic image for the copolymer of Styrene - Castor oil

The homopolymer of castor oil, showed IR absorption band at 1741 cm^{-1} (**Figure 4**).

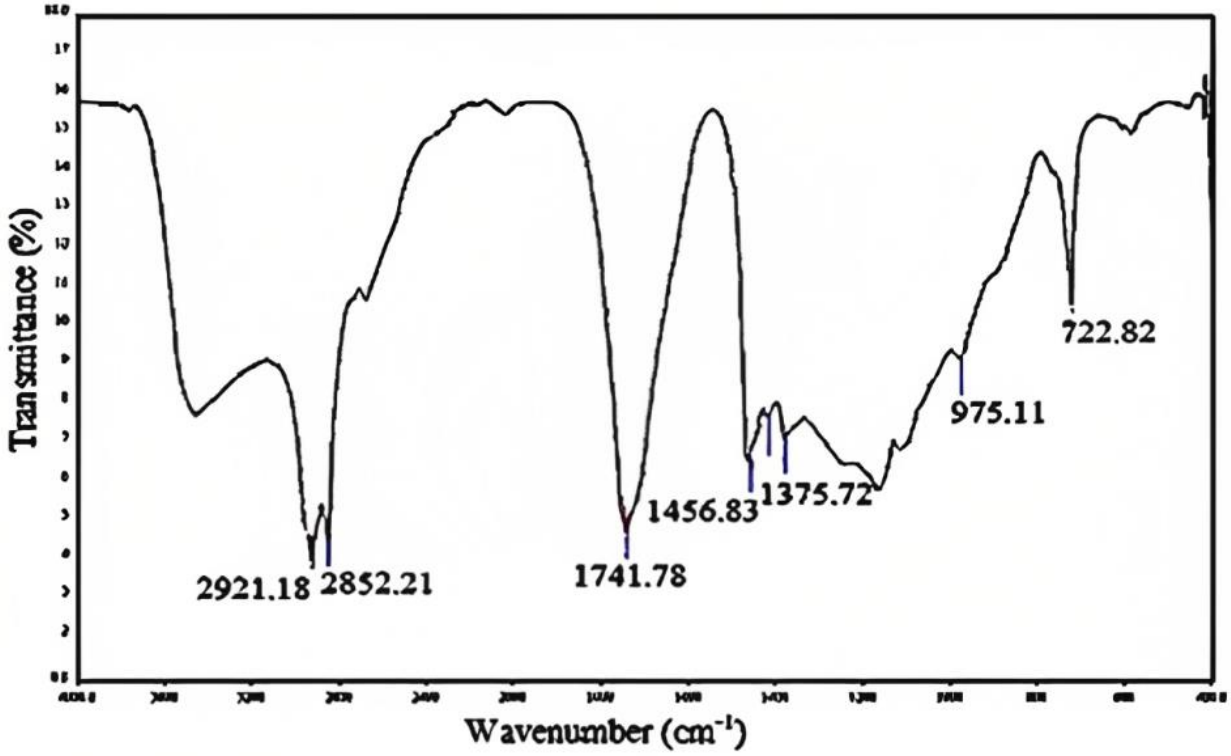

Figure S4: FT-IR spectroscopic image of the homopolymer of Castor oil

The ^{1}H NMR spectra of castor oil is presented in **Figure 5**. The peaks observed within 4.1 - 4.3 ppm, 0.8 - 0.9 ppm, 1.2 - 1.6 ppm and 2.2 - 2.3 ppm. **Figure 6** indicated the presence of protons from the -$COOCH_2$ group in castor oil, methyl protons, the methylene protons and methine protons specific to the alkyl chains.

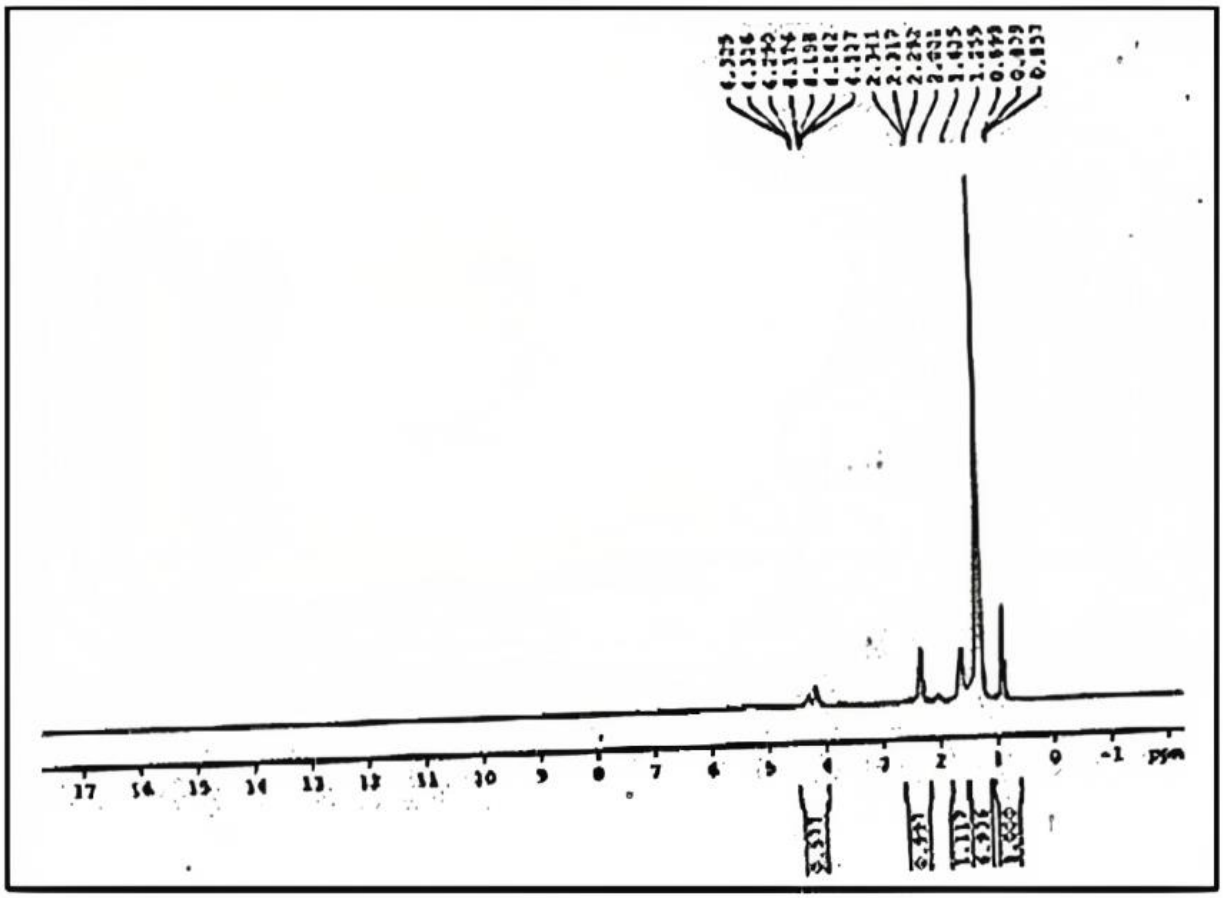

Figure S5: ^{1}H NMR spectroscopic image of homo polymer of Castor oil

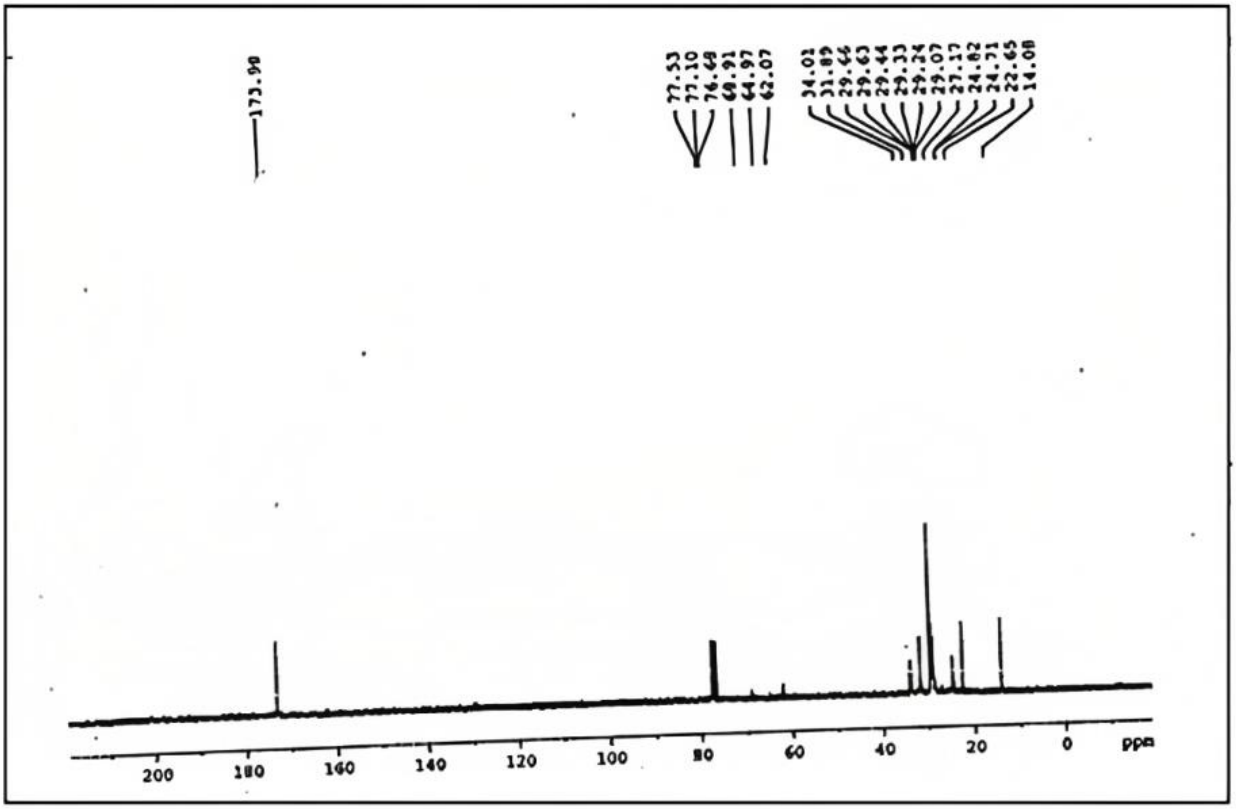

Figure S6: ^{13}C spectroscopic image of homo polymer of Castor oil

The Figure 6 represents the ^{13}C NMR spectra for the homopolymer of castor oil, where peak at 173.9 ppm represents ester carbonyl group and the peaks in the range 62.1 - 68.9 ppm represent the carbons of $–OOCH_2$ group (**Figure 7**).

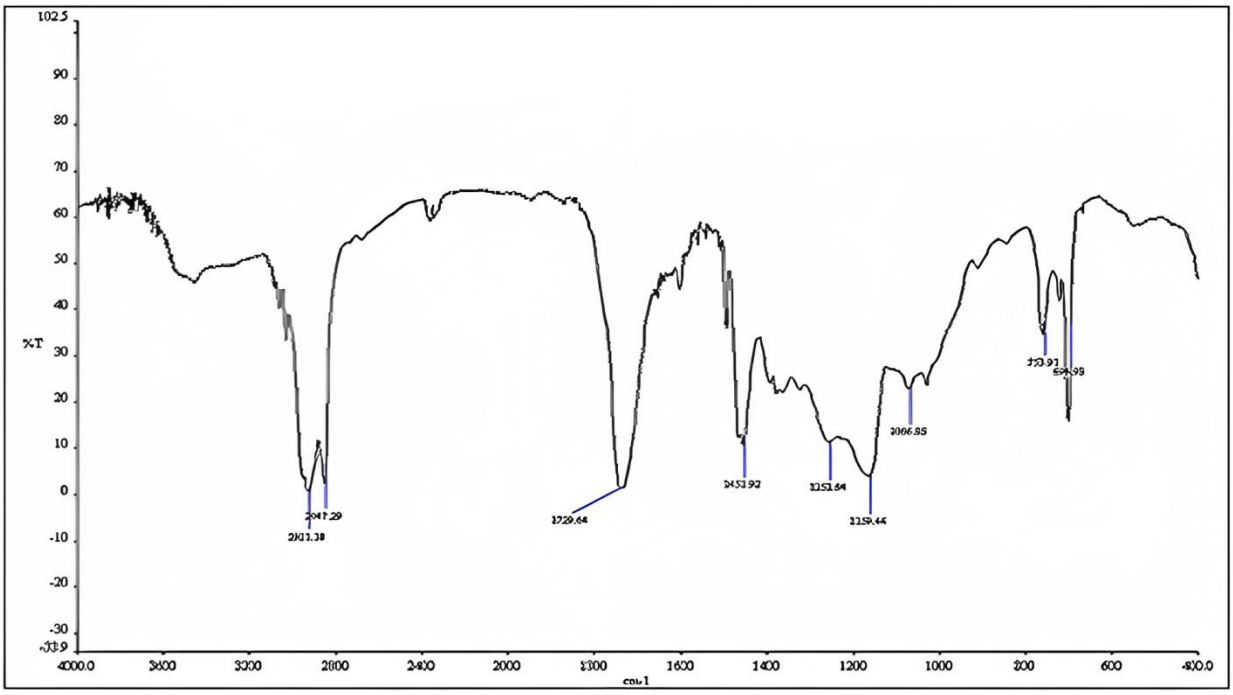

Figure S7: FT-IR spectroscopic image of the copolymer post biodegradability study