

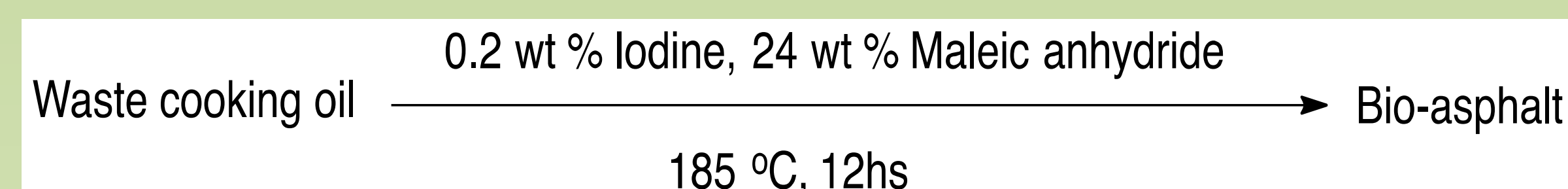
Introduction



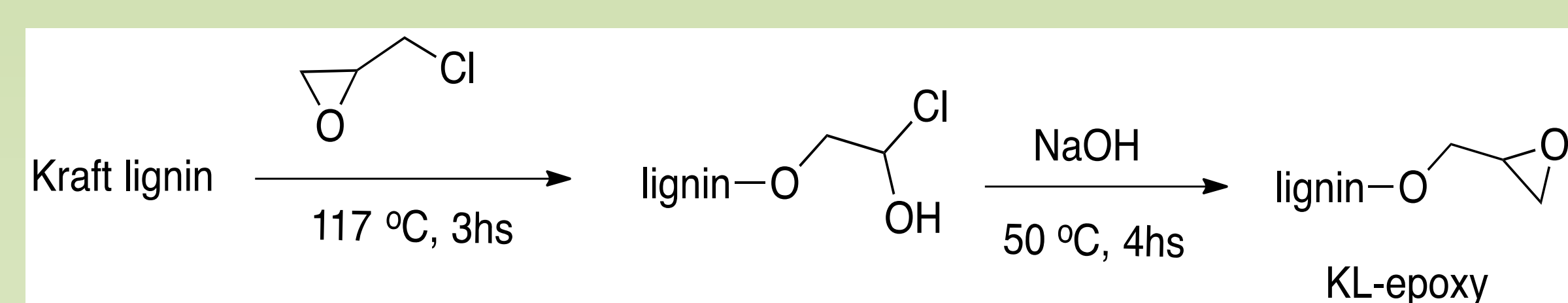
This research optimizes the production of Kraft lignin (KL)-based epoxy and waste cooking oil (WCO)-based bio-asphalt to achieve a comparable alternative to the commercial asphalt.

Methods and Materials

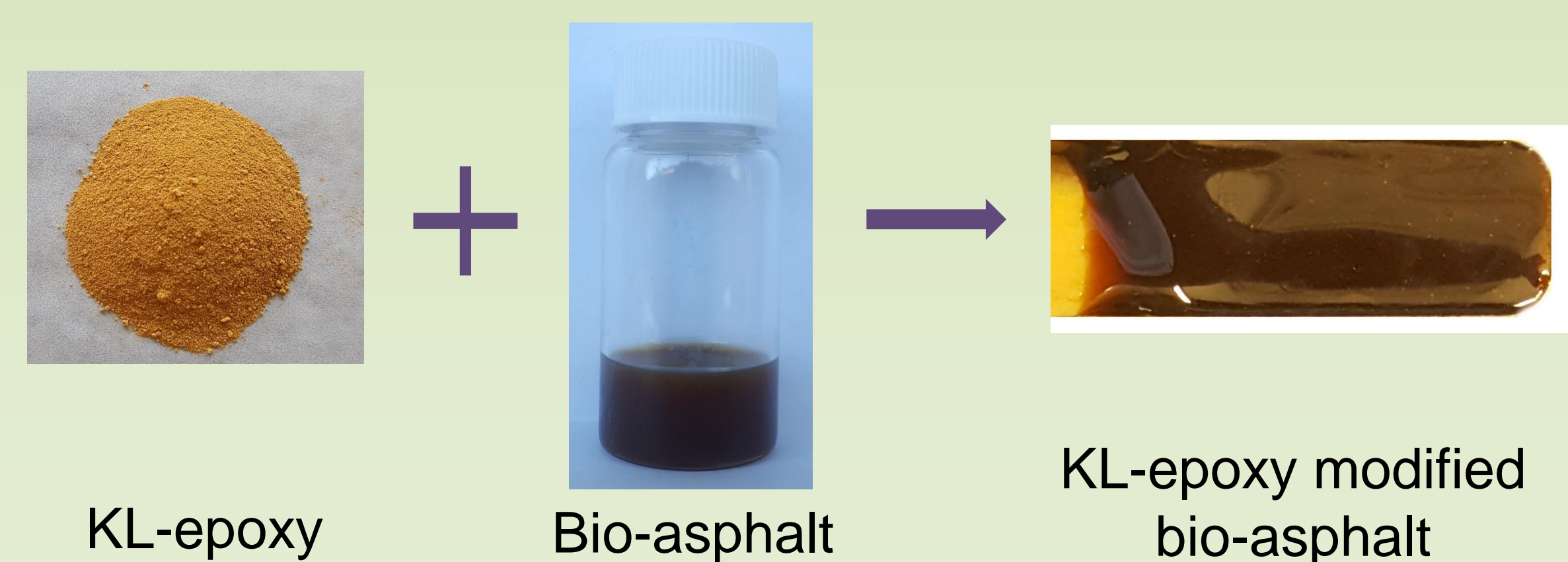
Synthesis of Bio-asphalt:



Synthesis of KL based epoxy monomer:



Reinforcement of bio-asphalt with KL-epoxy:



Characterization of Rutting Resistance & Viscoelasticity

❖ Studies performed using Parallel Plate geometry:

1. Effect of reaction time of Bio-Asphalt: 12 hours vs 24 hours
2. Effect of KL-epoxy contents: 2.5%, 5%, 7.5% or 10% by weight

← Discovery HR-2 Model Rheometer

Table 1: The molar ratios of each reagent for the glycidylation reaction of KL were as follows:

	Hydroxyls of KL	Epichlorohydrin	NaOH
KL-epoxy-1	1	10	1.1
KL-epoxy-2	1	30	1.1
KL-epoxy-3	1	30	3.3

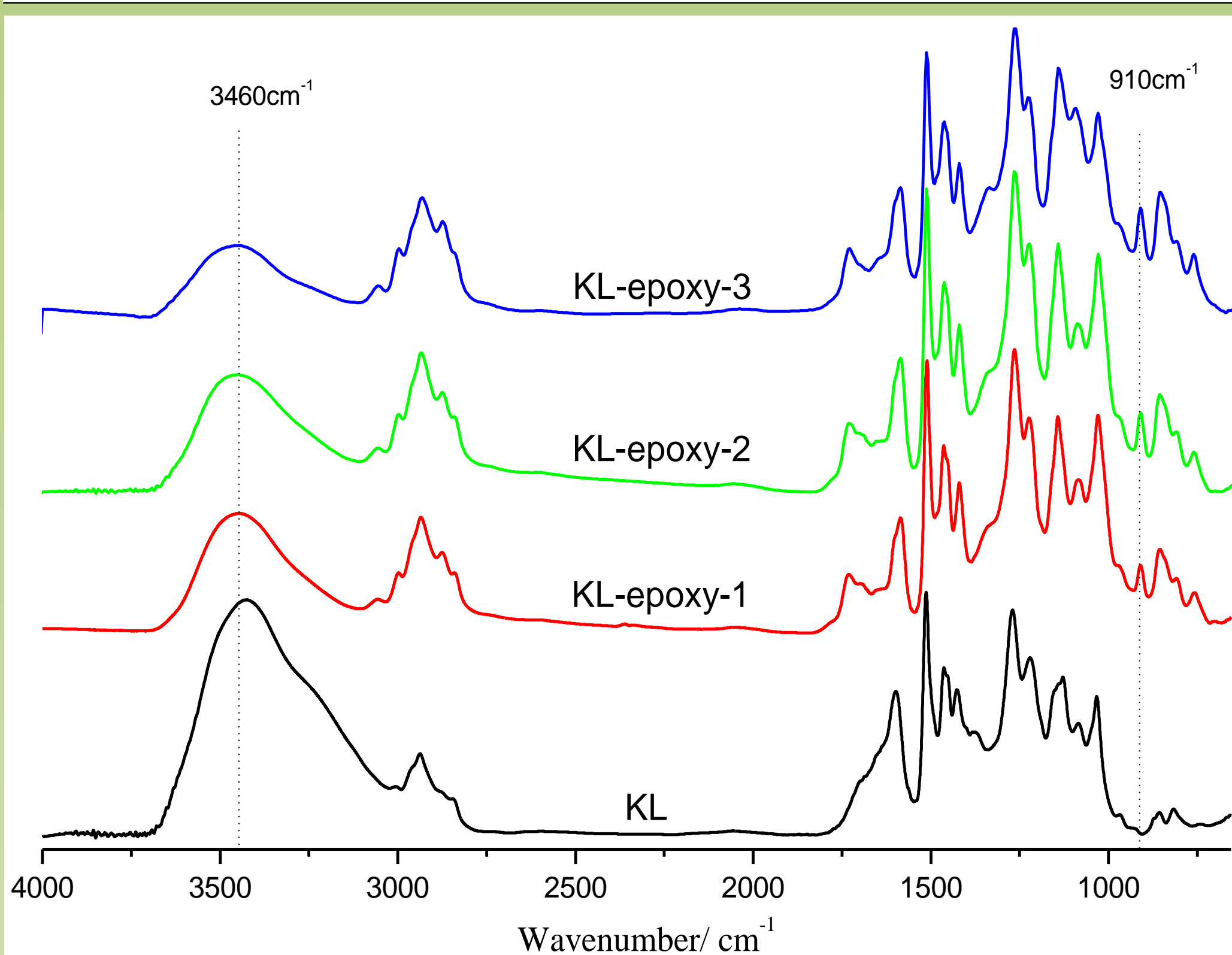


Figure 1: FTIR spectra of KL and different KL-based epoxies.

- ❖ Production of epoxy rings → Decrease of hydroxyl groups.
- ❖ KL-epoxy-3: highest production of epoxy highest reduction of hydroxyl

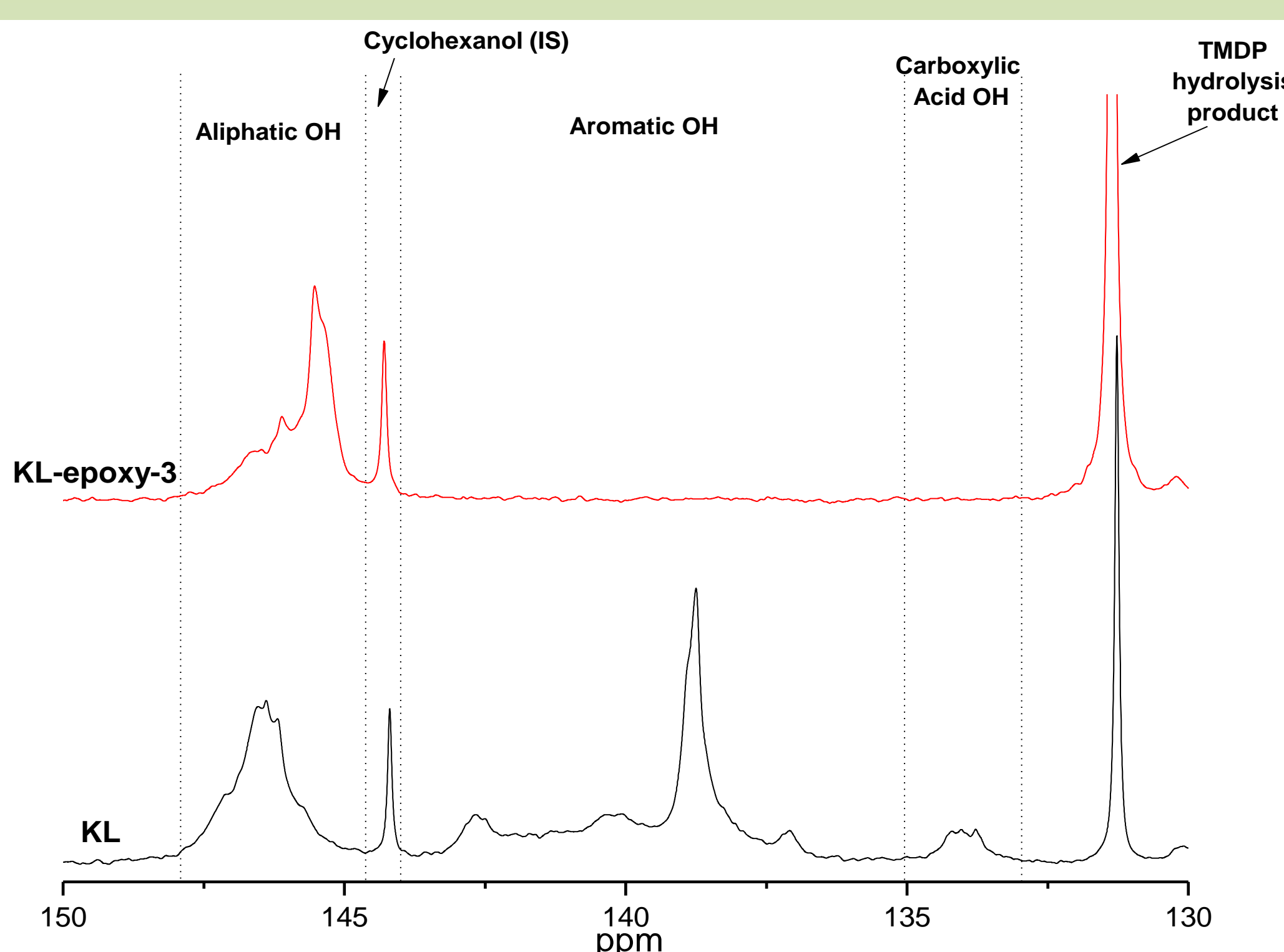


Figure 2: ³¹P NMR spectra for KL and KL-based epoxy

Table 2: Hydroxyl values of KL and KL-based epoxy estimated by ³¹P NMR

	Hydroxyl value (mmol/g)			Total
	Aliphatic	Aromatic	Carboxylic	
KL-epoxy-3	1.93	0	0	1.93
KL	2.44	3.40	0.13	5.97

- ❖ Aromatic hydroxyls
Carboxylic acid hydroxyls → totally → Epoxy
- ❖ Aliphatic hydroxyls → partially → Epoxy

Results

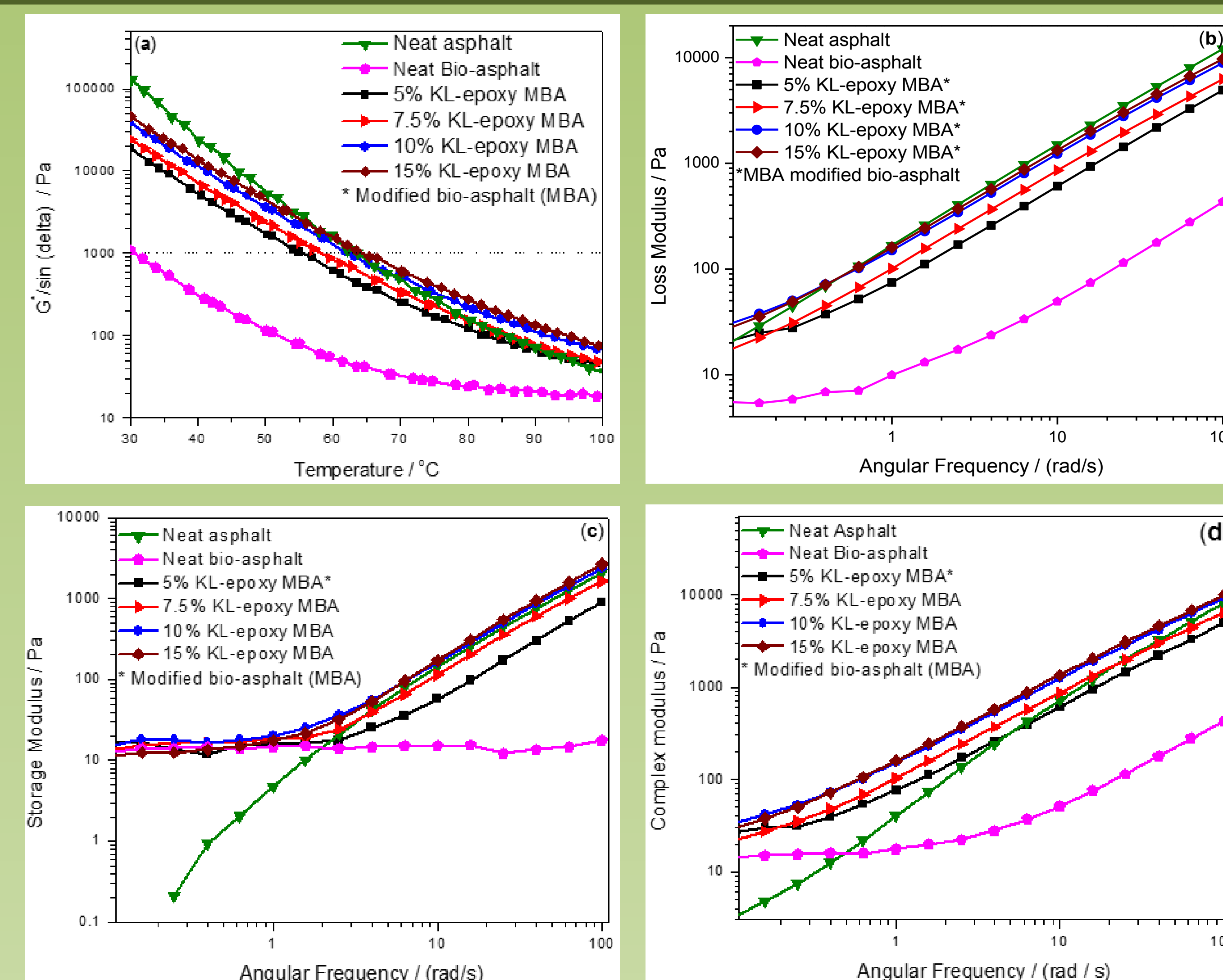


Figure 3: Rheological properties of neat asphalt, neat bio-asphalt and KL-epoxy modified bio-asphalt samples

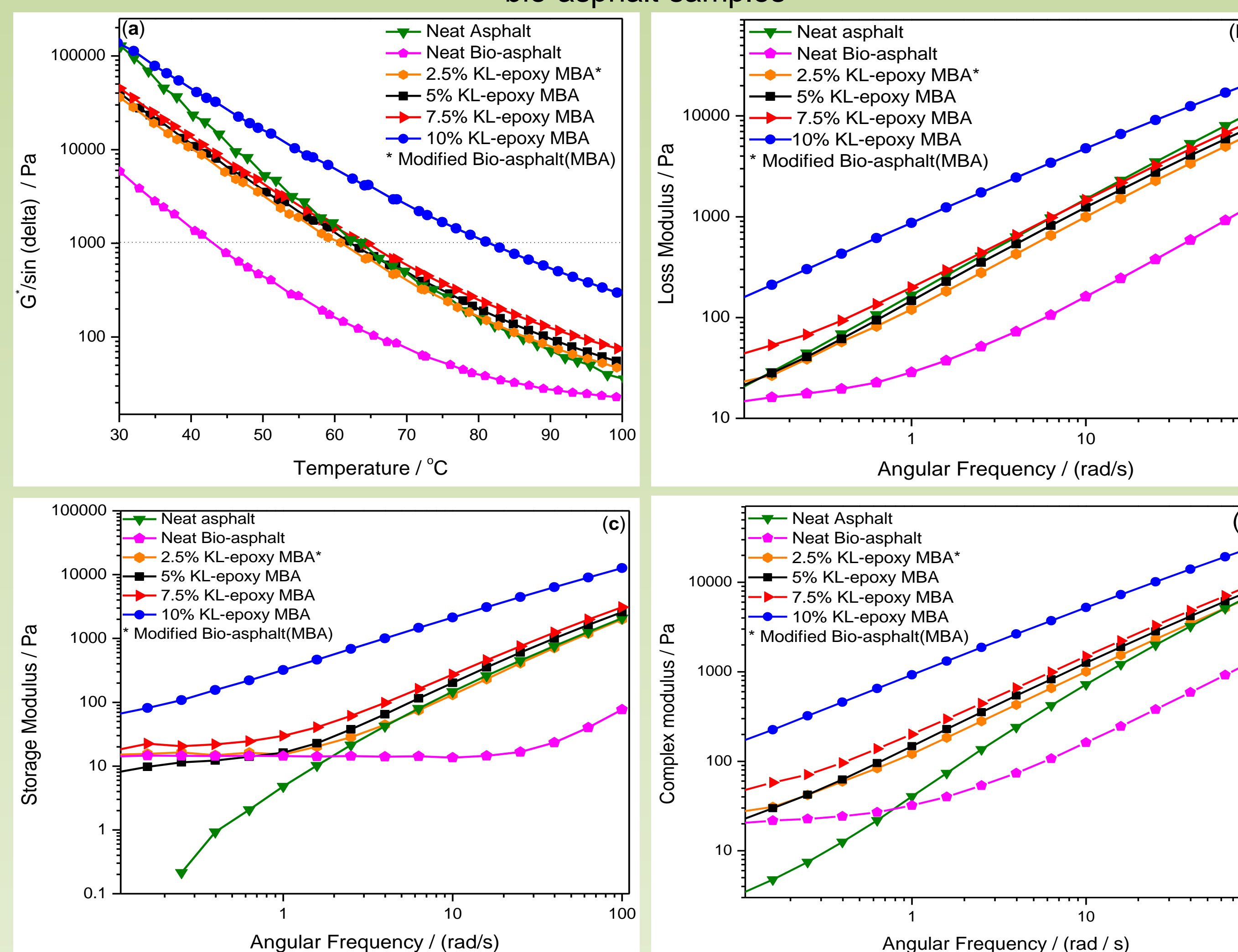


Figure 4: Rheological properties of neat asphalt, neat bio-asphalt and KL-epoxy modified bio-asphalt samples

The temperature at which $G^*/\sin(\delta) = 1$ KPa is the maximum temperature for effective asphalt performance.

Conclusion

- ❖ Addition of KL-epoxy has improved the high temperature performance and viscoelasticity of the bio-asphalt.
- ❖ The properties increased with the increasing of the KL-epoxy contents.
- ❖ By varying the KL-epoxy content, rheological properties of the modified bio-asphalt can be greatly regulated.

Acknowledgements

This work was supported by the National Institute of Food and Agriculture (NIFA), USDA Award Number: 2017-67032-26005.