OBJECTIVE:
Could we answer the following questions?

Does guayule resin have the potential to:
1. Replace asphalt cement (AC) in the asphalt pavement industry at specific grades (by itself or by adding an enhancer (e.g., crumb rubber modifier (CRM))?
2. Work as a new bio-based additive to AC or asphalt rubber (AR)?

BACKGROUND
Guayule resin, as one of guayule shrub derivatives, is inevitably extracted with guayule natural rubber (the only current valuable guayule derivative) production. Each kg of produced rubber is corresponding to about 1kg of resin, at least. There is almost no current value of this resin, just a byproduct (i.e., still under research). The only obstruction against utilizing Guayule Rubber, via previous hundred years, it is not economically affordable in its production cycle.

The solution to open the door towards this valuable source of natural rubber is economically affordable in its production cycle.

Why guayule resin?
• Guayule resin is an asphalt-like material (viscoelastic – mainly hydrocarbons).
• Present physical properties similar to asphalt at specific grades.
• Bio-based material and byproduct at the same time (i.e., renewable unlike asphalt).

SUBJECT MATEIRALS & SAMPLING
Materials
• Asphalt cement, AC (FC25-28): Source: Conoco Phillips Terminal at Granite City
• Guayule Resin BGR: Source: Bridgestone Americas Center from Research and Technology (BART)
• Crumb rubber modifier (CRM 30-40), i.e., retained between mesh 30 and mesh4)

Sampling
• 15 designated binders (divided into six subsets: Neat AC, Neat BGR, Neat BGR+CRM, AC+BGR, AC+CRM, and AC+BGR+CRM) All of them were studied (OB vs. RTFO), whereas eight of selected binders proceeded with PA V.

Blending:
• High shear mixer (HSM-1001CL-T)
• Dual-rotor mixing machine (Max-Cell 100C M112) and temperature control unit (Degi-Sence TS100)

For testing:
• Relative Viscometer (RV): unaged binders’ dynamic viscosity
• Dynamic Stress Rheometer (DSR): unaged and RTFO aged binders: elevated temperature grades, short term aging
• G’Simp/Master curve for unaged binders
• Binder Bending Rheometer (BBR)
• RVA binder’s low temperature grade
• Rolling Thin Film Oven (RTFO)
• Master curves for short term aging
• Pressure Aging Vessel (PAV)
• Superpave asphalt cement (AC) grade

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RESULTS (Following questions’ answers in “FINDINGS”, in order from A to G)

(A) Do CRM concentrations & interaction time and temperature affect the dynamic viscosity of the guayule-rubber binders? (B) Compared to the neat asphalt viscosity, could BGR present lower mixing and compaction temperatures? (C) Does BGR age the same way of AC using the scale of AC Standard regarding the elevated temperature grade? (D) Could BGR provide an acceptable binder regarding the intermediate temperature grade (fatigue resistance)? (E) Do master curves provide something different than what gradient system provided?

FINDINGS

(A) Yes – significant effect – Neat BGR viscosity is 114±4, compared to 309±4 for AC (at 135°C) increased to about three times with 10% CRM and about 7.5 times with 25% CRM.

(B) Yes – at 170±20°C, BGR has a mixing temperature range of 124.5–129°C. At 170°C, BGR has a temperature range of 119°C.

(C) Yes – Approaching the AC minus guayule-based binder indicated a resultant elevated temperature grade of unaged binders (corresponding to G’Simp/1 of 1 kPa) reasonably compared to the reported one to the RTFO aged binder (corresponding to G’Simp/1 of 2.2 kPa).

(D) Yes – all guayule-based binders accomplished 25°C at intermediate temperature grade except for RTFO, while AC produced 16°C significant difference. However, all guayule-based binders accomplished at least the minimum requirements concerning Superpave specs except for BGR indicating the more BGR treatment the better the resulting material.

(E) Yes – Even though, all trends almost seem to be normal considering the grading system. Neat BGR provided the so-called ascending sag curve (ASC) – Yes, it seems to have a lower trend than others at higher frequencies, but at lower frequencies (0.5 Hz) provides a much better performance than others. That could take our thinking in the future to direct our research towards how to exploit BGR in low frequency applications (e.g., parking lots and traffic queues).

(F) No – unfortunately guayule-based binders yielded a high mass loss when applying the AC specs – indicating that BGR has very low molecular weight components that are easily evaporated during the short term aging simulation (RTFOT) – Further investigation is required in the future.

(G) Relatively, no – Whether Neat BGR or CRM-modified BGR binders resulted in a low temperature grade of –10°C, but at least BGR has the potential to provide binders acceptable at specific grades upon the location of utilization environment, economics, and sustainability.

CONCLUSIONS
• BGR could provide binders with lower viscosity than the corresponding AC (reflecting more construction, cost savings and workability).
• 20% of CRM enhanced BGR by about one grade, compared to about 4 grades for AC.
• Master curves expose the significance of guayule that could be exploited at very low traffic speed applications (e.g. parking lots and traffic queues).
• Mass loss was observed significantly high, compared to AC. However, mass change is a debatable issue, determined ±1% by specs for AC regarding the environmental aspect which is not the main focus regarding this binders.
• Furthermore, many studies activated upon bio-based binder studied in high mass losses as well.
• Upon BBR testing, results indicate a pass at 0°C testing temperature for all guayule-based binders. However, all did not pass at lower temperatures. Adding 10% or 20% CRM do not denote a positive behavior of the designated binders at lower temperatures.
• Ultimately, the guayule resin has the potential as a bio-material to break through the asphalt (flexible pavement) industry, as it has the potential to contribute with economic, environmental and sustainable targets.

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Any perspectives, outcomes, discussions, and conclusions expressed in this study, those of writer(s).