Reinforcement of Charcoal Activated Carbon (CAC) in Natural Rubber (NR) Compound: In Comparison with Carbon Black

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PRESENTATION OUTLINE

- ✓ Introduction
- ✓ Experimental
- ✓ Results and Discussion
- ✓ Conclusion
- ✓ References
- ✓ Acknowledgements

INTRODUCTION

- Natural rubber (NR) is the high scale, bio-based material among rubbers and has production system which are environmental friendly compared to the synthetic rubbers [2].
- Carbon black (CB) is one of the filler that has been used to prepare polymer composites with high exhibitions.
- According to Thaptong et al. [3], using carbon black as the filler in rubber compounding can lead to increment the ultimate strength, modulus and abrasion resistance and silica is the most competitor to carbon black in ability of reinforcing filler.
- Charcoal produced from carbonized woods or animal's bones used mainly as fuel.
- Charcoal is not only advantageous as a source of energy but also potential to be created with the activation method become activated carbon.
- As stated by Meng et al. [5], the unstable of the cost of petroleum has promote higher attraction to incorporate filler from renewable resources with polymeric materials instead of using reinforcing filler in recent year.
- Bamboo charcoal powder was used to replace conventional filler in styrene butadiene rubber and increasing in temperature of thermal decomposition steadily as stability of the thermal compound become better [5].

EXPERIMENTAL

Materials

- Natural Rubber (SMR-10)
- Charcoal Activated Carbon (CAC)
- Carbon Black
- Zinc Oxide
- Stearic Acid
- polymerized 2,2,4-trimethyl-1,2-dihydroquinoline (TMQ)
- Mercaptobenzothiazole (MBT)
- Sulphur

Formulations

Ingredients (phr)	10 CAC	15 CAC	10 CB	15 CB
NR (SMR 10)	100	100	100	100
Zinc Oxide	5	5	5	5
Stearic Acid	2	2	2	2
TMQ	2	2	2	2
CAC	10	15	-	-
CB	-	-	10	15
MBT	1	1	1	1
Sulphur	2.5	2.5	2.5	2.5

EXPERIMENTAL cont.

Compounding & Testing

Rubber Compounding

Mastication of NR (SML-10) using two-roll mill for 5 mins

→ Adding compounding ingredients in sequence →

1. Zinc oxide
2. Stearic acid,
3. TMQ
4. CB or CAC filler
5. MBT
6. Sulphur

→ The compounds were sheeted out by passing the rolled batch endwise through the mill nip 6 times.

** The compounding process was carried out within 25 minutes. The nip gap were 3 mm, 2 mm and 0.6 mm for masticating and mixing process while homogenize process was carried out at 1.2 mm of nip gap.

Curing Characteristics

- ✓ Moving Die Rheometer (Hung Ta Instrument Go. Ltd)
- ✓ Test was run at 170°C on an oscillating disk rheometer
- ✓ ASTM D-2084. The rubber samples were cut in square form in the range 6-8 grams then were covered with plastic film.
- ✓ The rheometric analysis determine the minimum torque (M_L), maximum torque (M_H), scorch time (t_{S2}) and optimum vulcanizing time (t_{c90}).

Hardness Test

- ✓ Hardness test Shore A
- ✓ Hilderbrand hardness tester
- ✓ ASTM D2240.

Tensile Test

- ✓ Universal Instron Tensile Machine
- ✓ ASTM D412
- ✓ Crosshead speed of 500 mm/min
- ✓ gauge length of 25 mm.
- ✓ Dumbbell shape (2 mm thick x 6.0 mm width)

Density Test

- ✓ ASTM D1817.
- ✓ The weight of the samples for the density test were in the range of 1 to 1.5 grams.

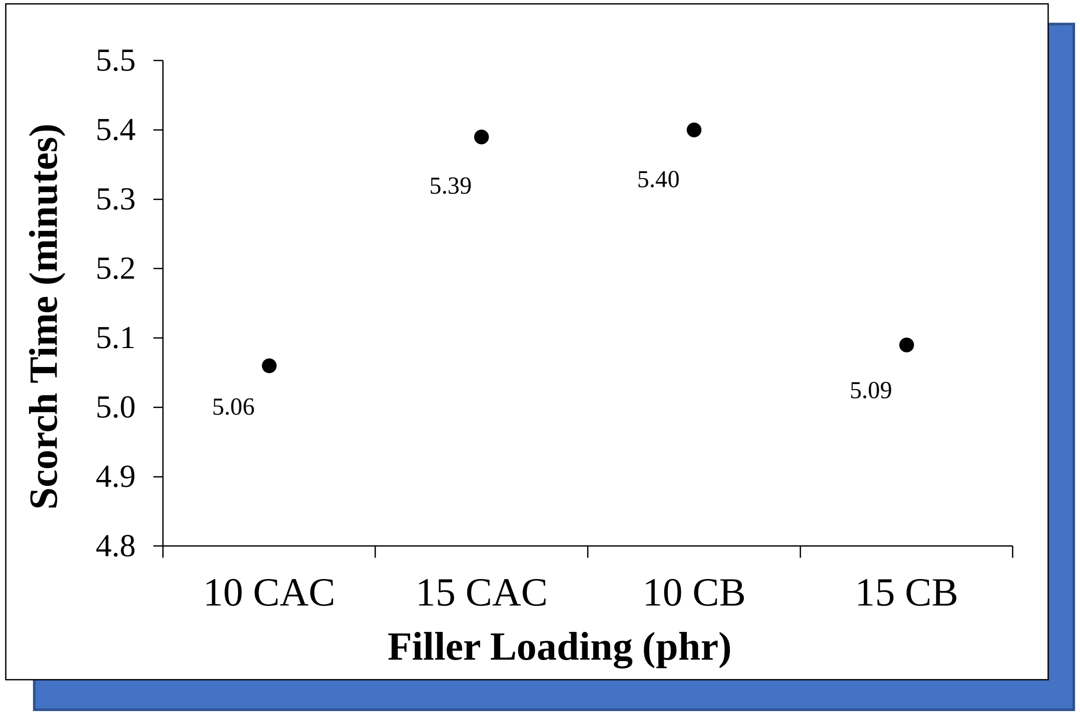
Swelling Analysis

- ✓ ASTM D471 (Toluene solvent)
- ✓ Sample's dimension of 10 mm in length x 10 mm in width x 2 mm in thickness.

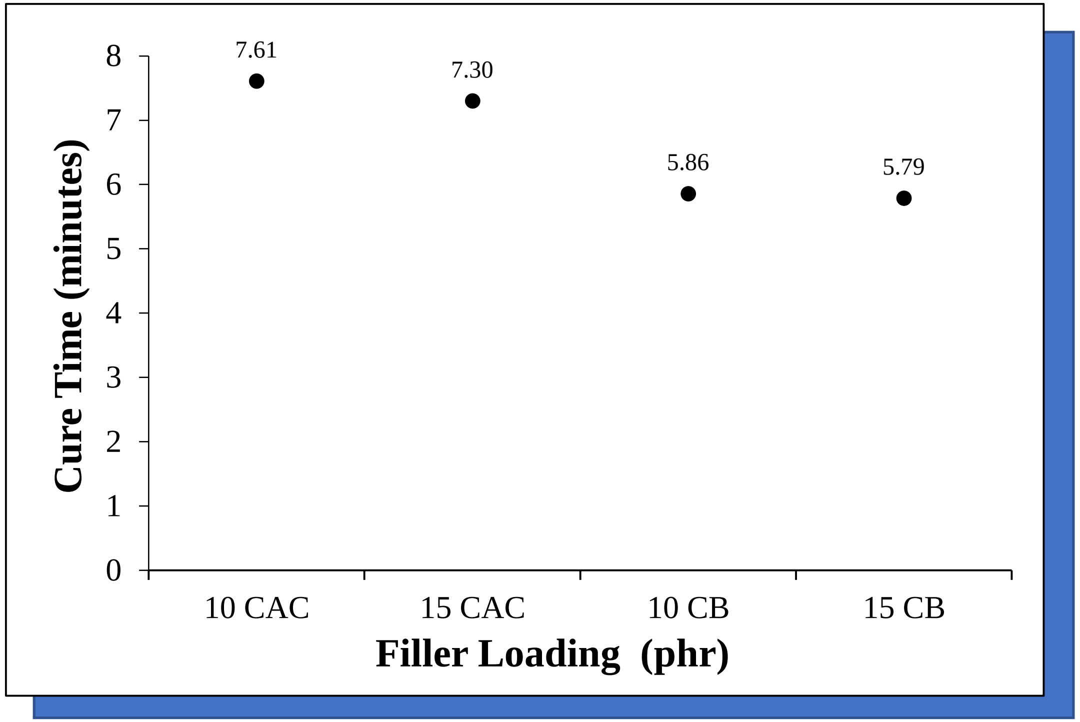
RESULTS & DISCUSSION

Cure Characteristics

Scorch Time (t_{s2})

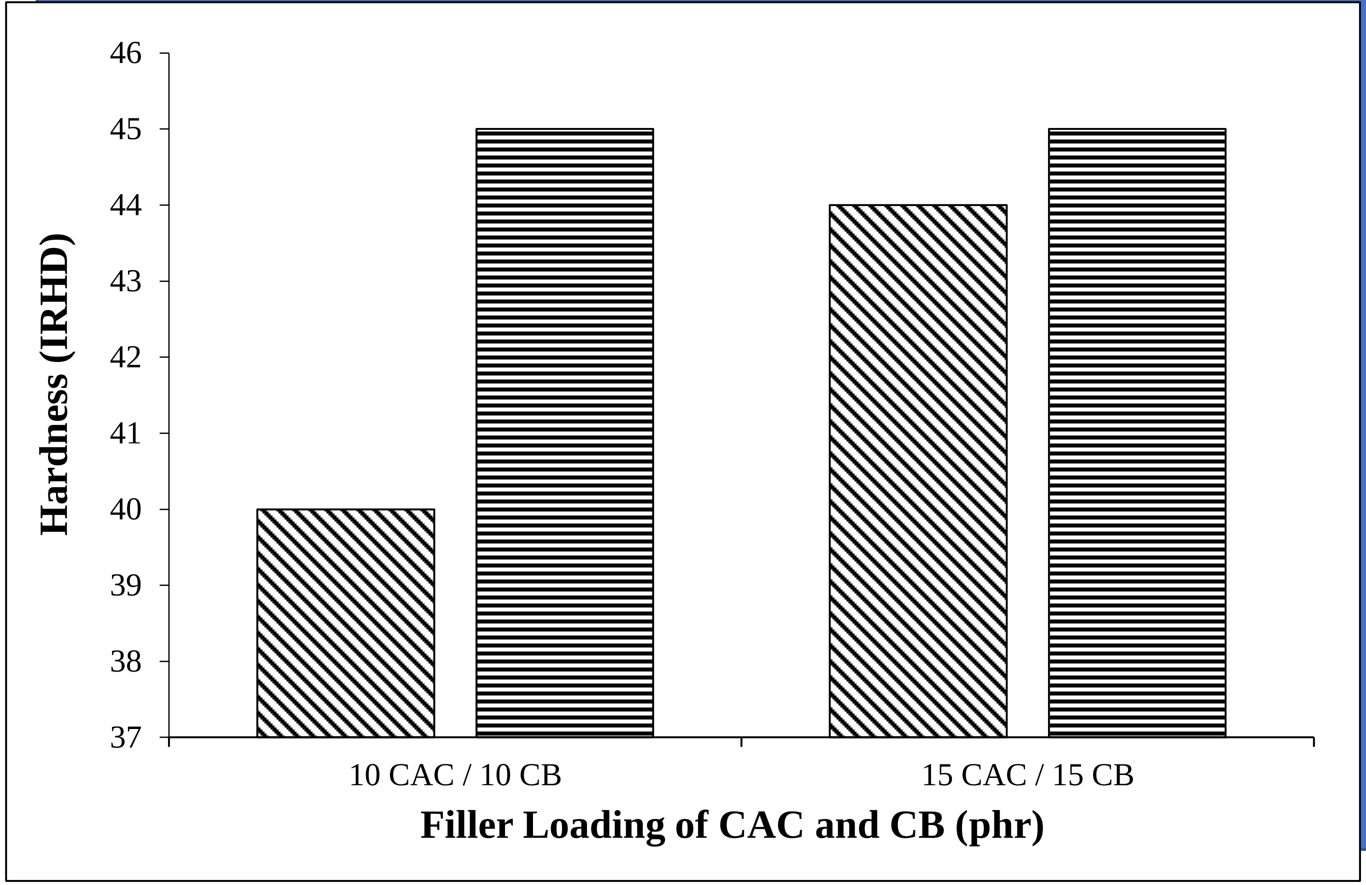


Cure Time (t_{c90})



RESULTS & DISCUSSION cont.

Hardness

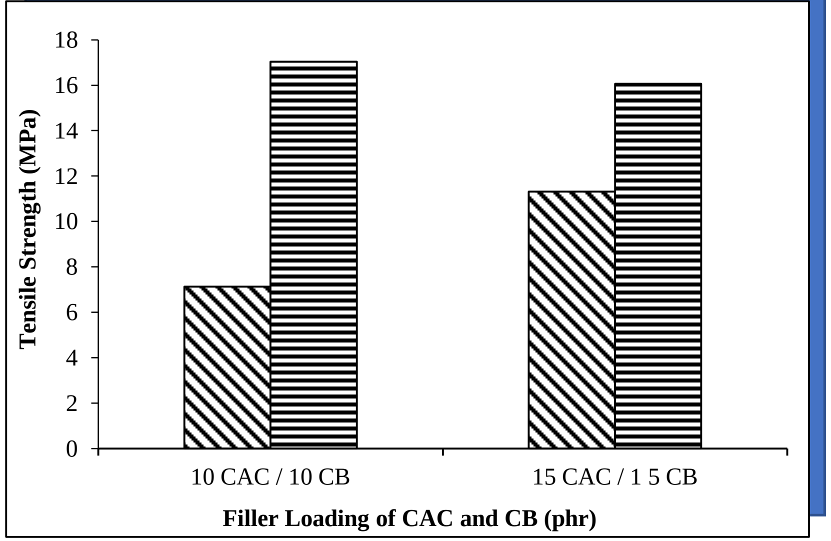


- The hardness was influenced by the stiffness of the compound.
- Increasing hardness value with increasing CAC loading showed that the addition of CAC loading in NR matrix leads to linear increased in the material hardness.
- But for hardness values of CB loading has no effect even with increasing of filler loading.
- It can be concluded that an uneven distribution of excessive CB in the rubber compound that resulting the less stiffness even with higher filler loading [13].

RESULTS & DISCUSSION cont.

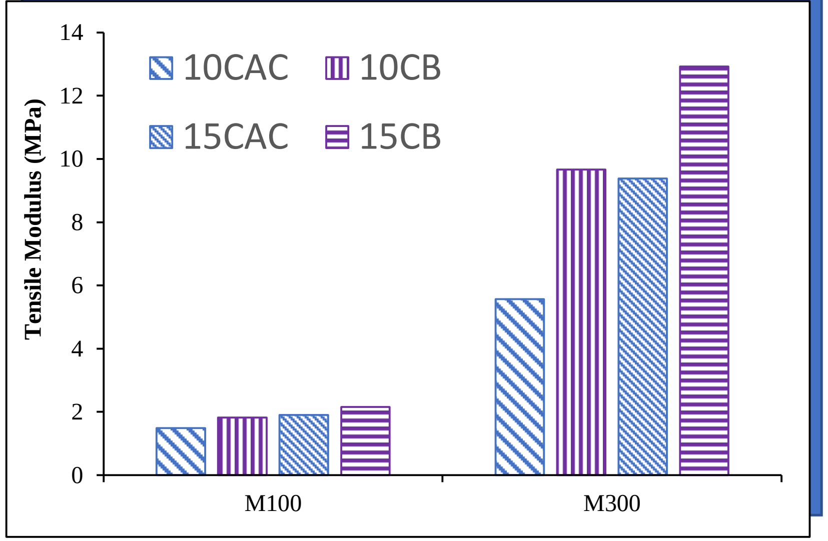
Tensile Properties

Tensile Strength



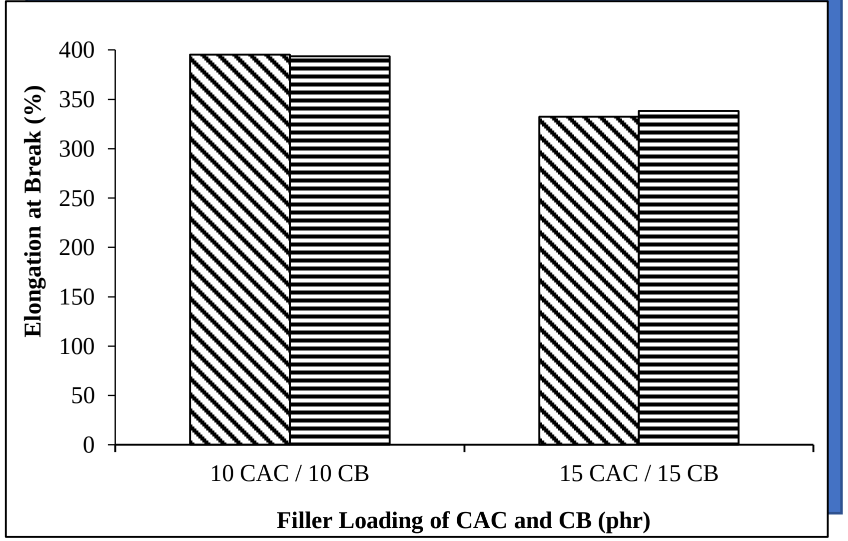
- Tensile strength increased with the addition of CAC.
- With the better dispersion of CAC, the excellent frame structure could support the transferred from the matrix.
- the tensile strength decrease with increasing loading of CB.
- Higher amount of CB leads to the interfacial interaction reduction due to the agglomeration of CB [16].

Tensile Modulus



- The tensile modulus increased with the addition of CAC.
- This indicated the elasticity of the rubber chain was reduced with the addition of CAC.
- Tensile modulus increase with the CB content.

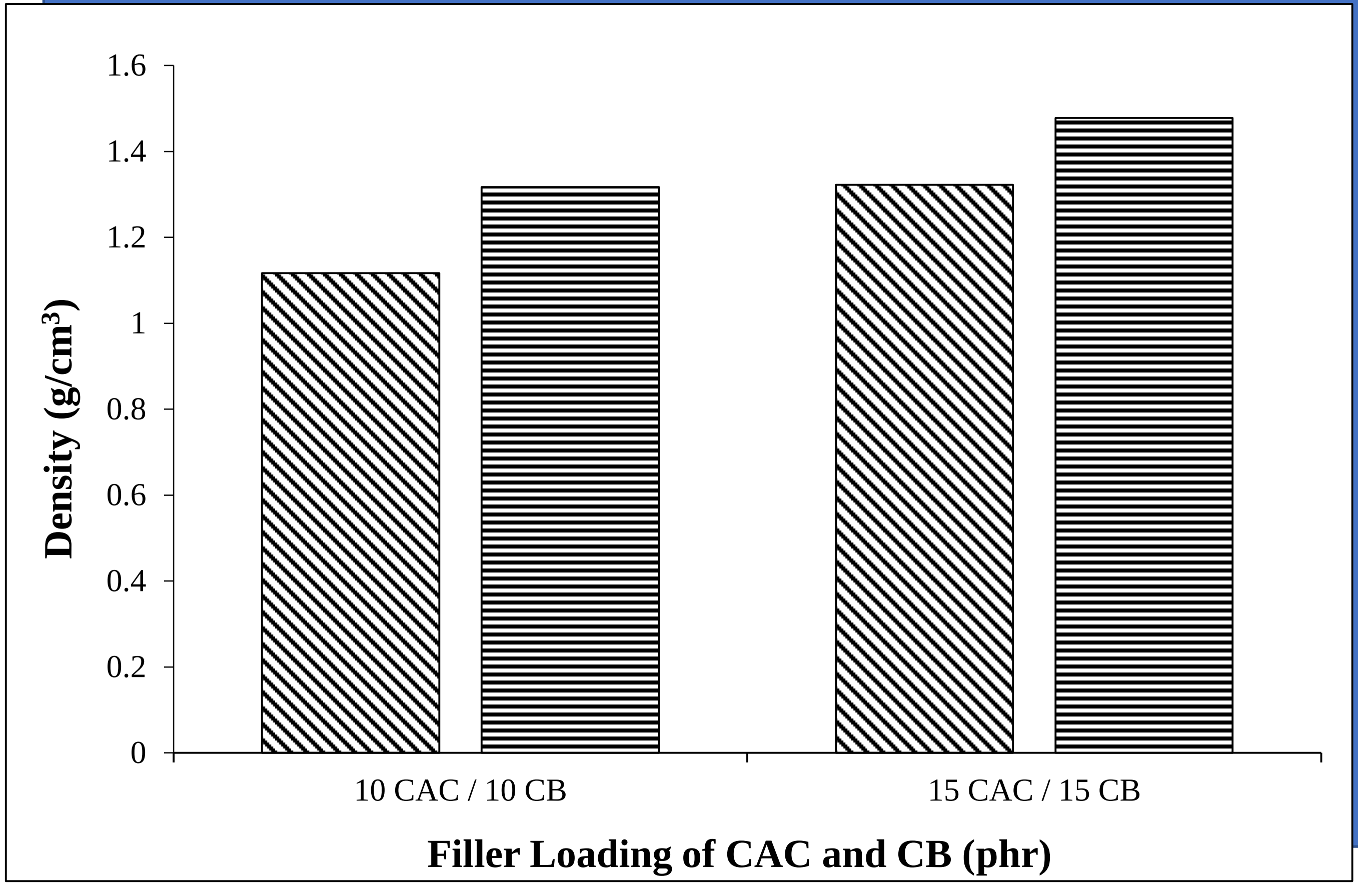
Elongation at Break



- Elongation at break was decreased with increase CAC and CB content.
- Weak interaction between CAC and CB with the rubber matrix that affected the decreasing of the elongation at break.
- Addition of CAC and CB in NR compound which increased the crosslink density, agglomeration and bound rubber can be accounted by the reduction of elongation at break.

RESULTS & DISCUSSION cont.

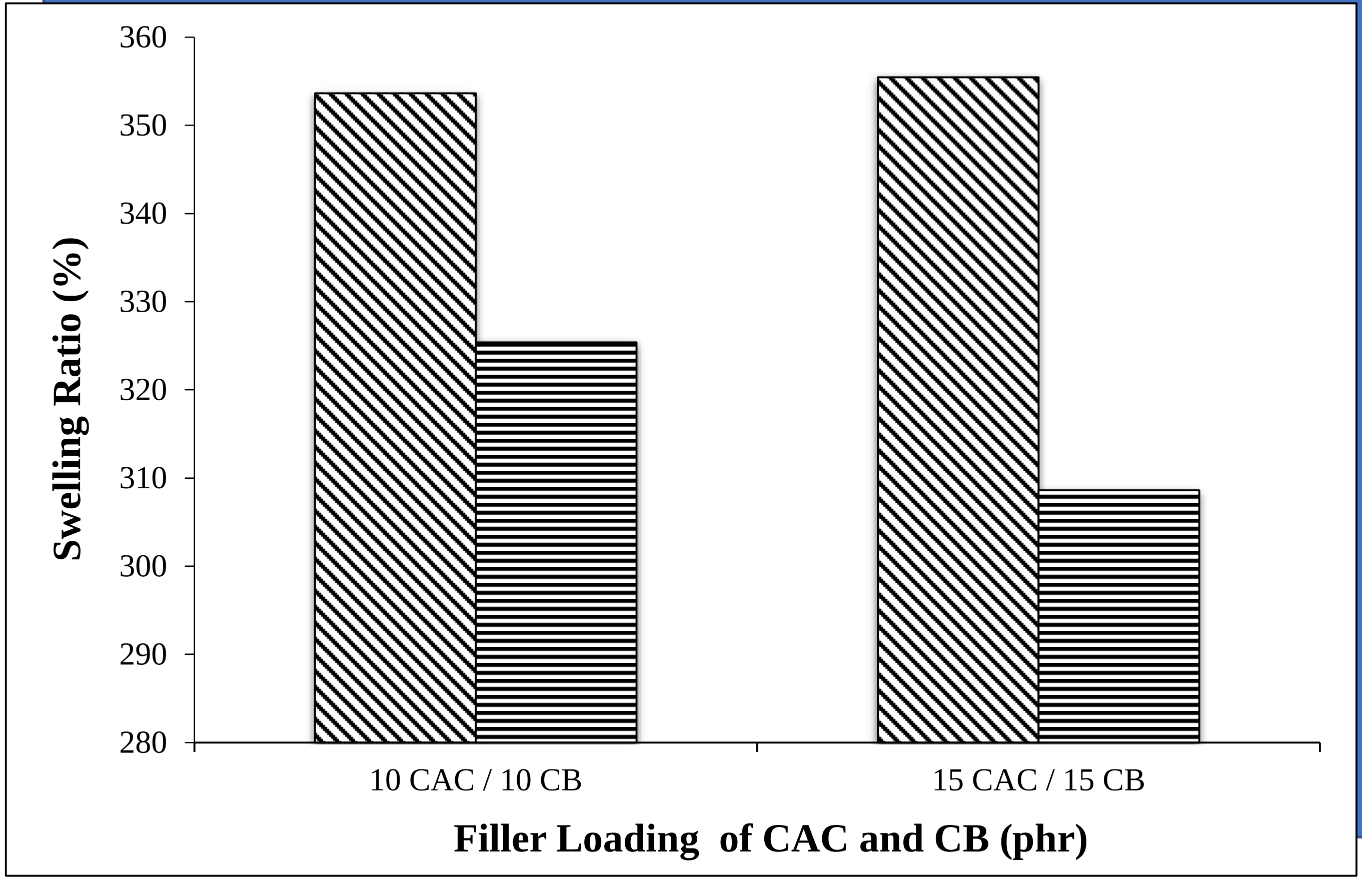
Density Analysis



- Increment in density value is more pronounced in NR/CB composite than in NR/CAC composite.
- Associated with the difference in the extent of reinforcement imparted by two different types of filler, which vary in particle size and non-polar nature of CB.
- Density of NR/CAC composite is lower due to the incompatibility between filler and rubber matrix caused by porous structure of charcoal that led the rubber composite less denser.

RESULTS & DISCUSSION cont.

Swelling Analysis



- Swelling ratio slightly increased with increasing CAC content in rubber composite.
- This increasing of swelling ratio showed that the addition of charcoal activated carbon in the rubber composite leads to linear increased in the materials swelling.
- Swelling ratio for CB composites showed decreasing trend with increasing CB loading.

- The difference in the swelling ratio of NR/CB and CAC/CB was apparent.
- The higher swelling ratio of CAC was possibly due to the original channel and porous structure so the rubber composite in swelling ratio increase with increasing CAC loading.

CONCLUSIONS

Influence of CAC as filler in NR compound on cure characteristics, mechanical properties, and swelling ratio had been investigated. Optimum cure time, scorch time, tensile strength, elongation at break and swelling ratio of the 15 CAC compound were comparable with the commercial grade of CB. Hence, CAC has good potential usage as filler in NR compound, but not for high strength applications.

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ACKNOWLEGMENTS

The authors would like to relay our gratitude to the Faculty of Applied Sciences, Universiti Teknologi MARA, Arau Campus and Shah Alam Campus for the facilities and financial provided.