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UNIVERSITÀ DI PISA



ecopneus

il futuro dei pneumatici fuori uso, oggi

**dott. Giovanni Nicola Vitticano**

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# RECYCLED POLYMER APPLICATIONS IN BITUMINOUS SLEEVES: OPPORTUNITIES FOR A CIRCULAR ECONOMY

Macrogiovani 2018 – Fisciano (SA)

15/06/2018

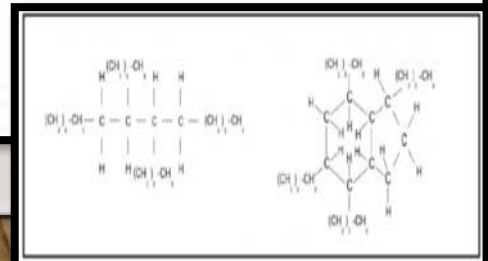
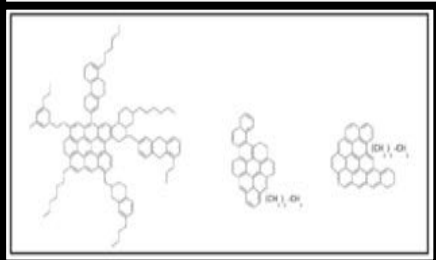
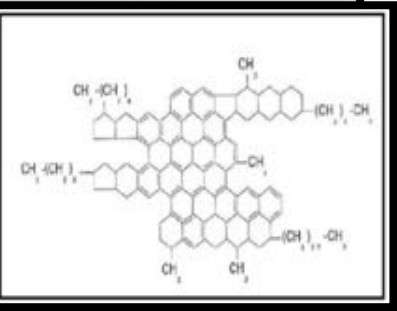
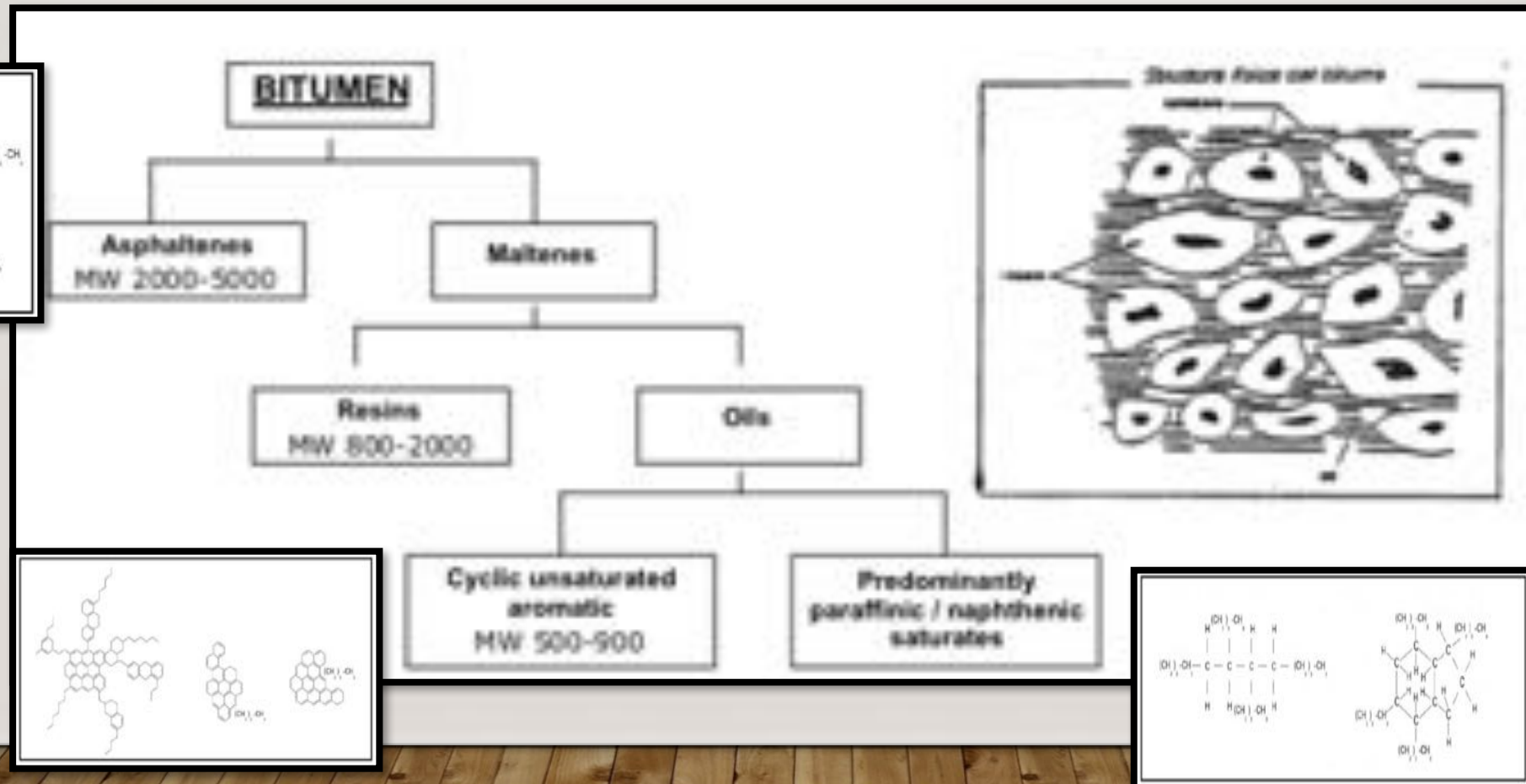


Associazione Italiana  
di Scienza e Tecnologia delle Macromolecole

# CIRCULAR ECONOMY



# BITUMEN COMPOSITION





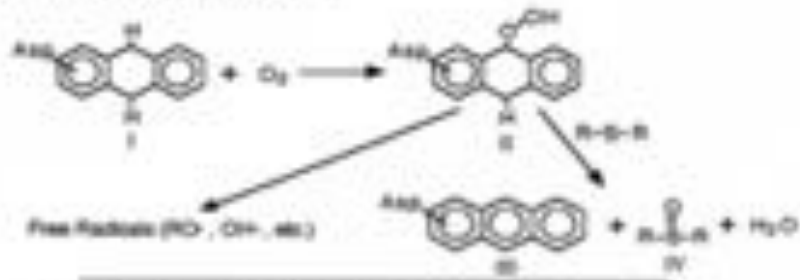
# MAIN APPLICATIONS

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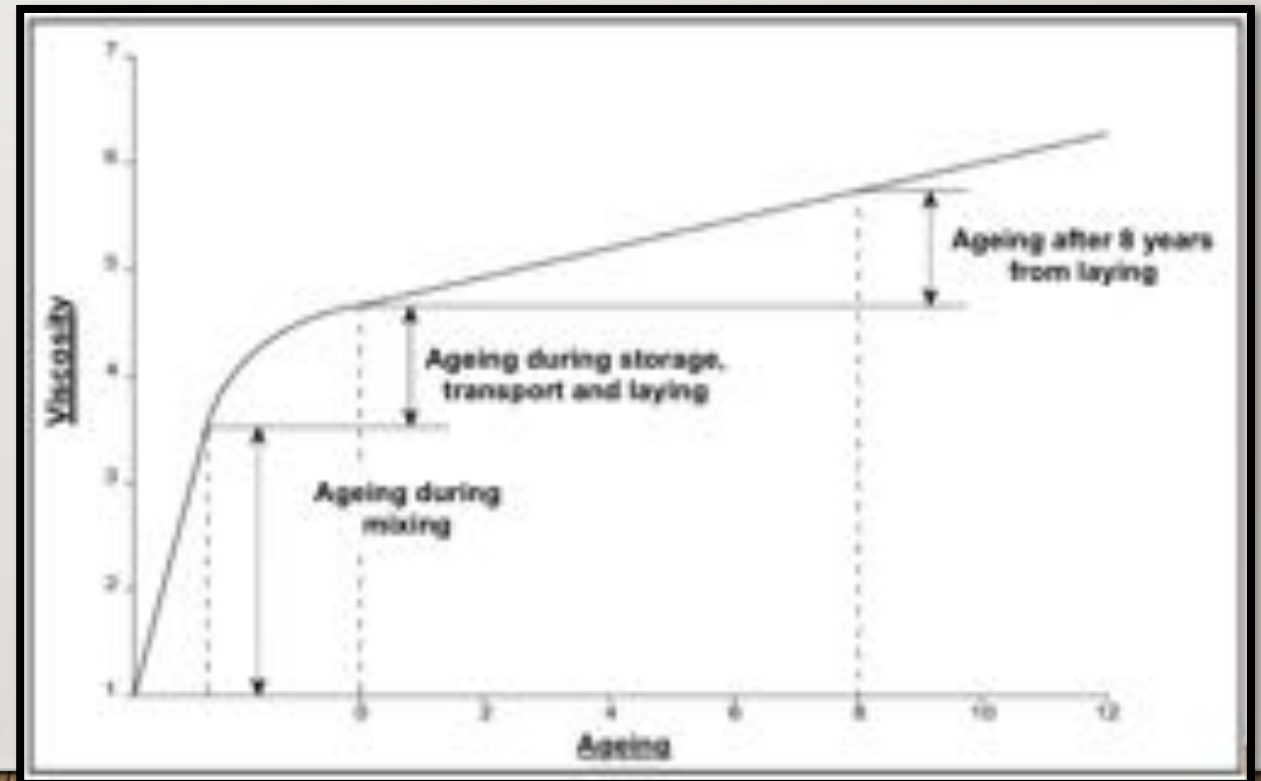
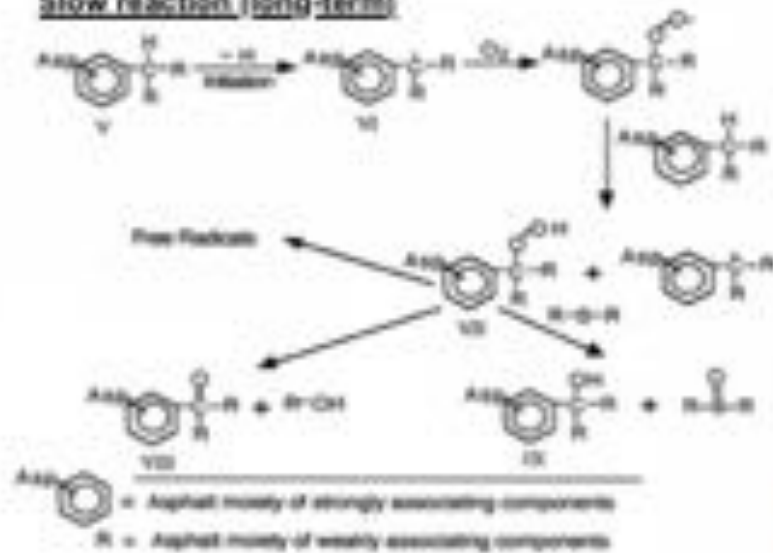


# AGEING OF BITUMEN

## Quick reaction (rush)



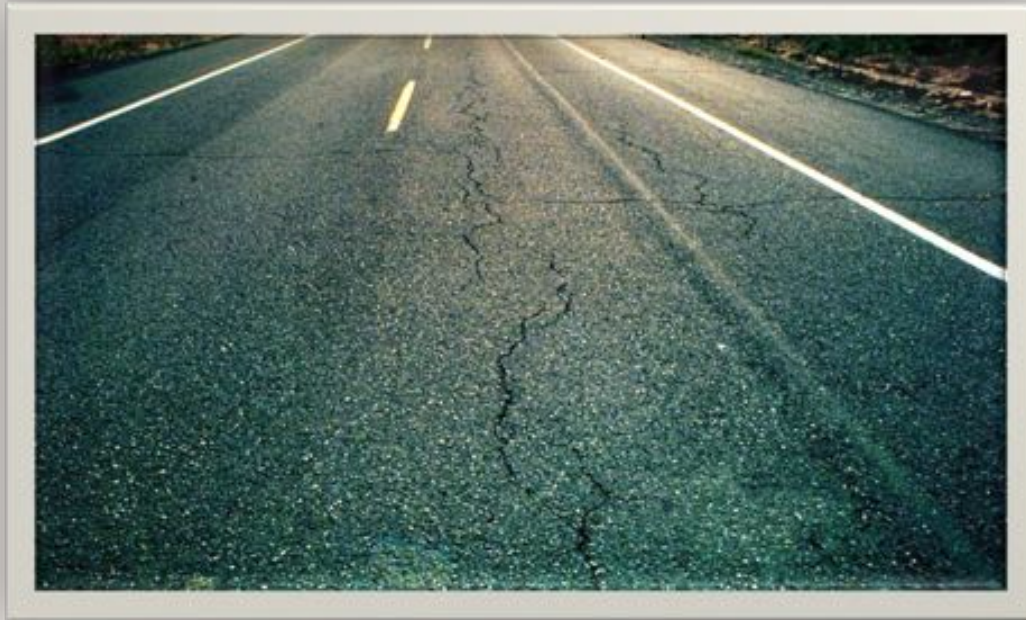
## Slow reaction (long-term)





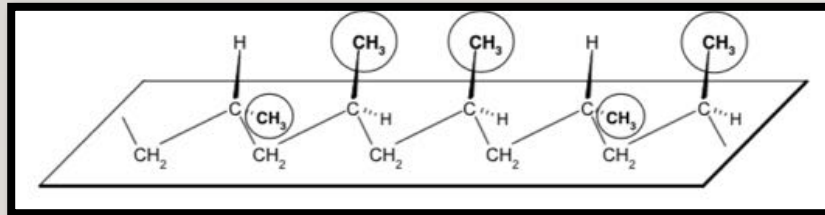
# NEGATIVE ASPECTS OF AGING

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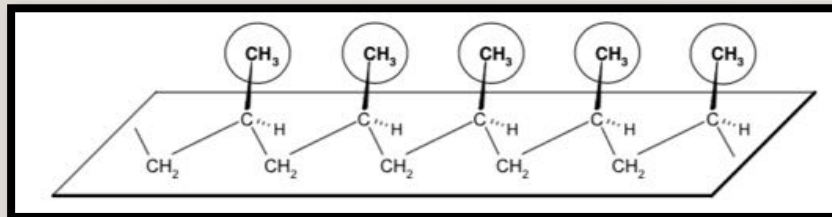


# MODIFICATION OF BITUMEN WITH POLYMER

## Mixes APP

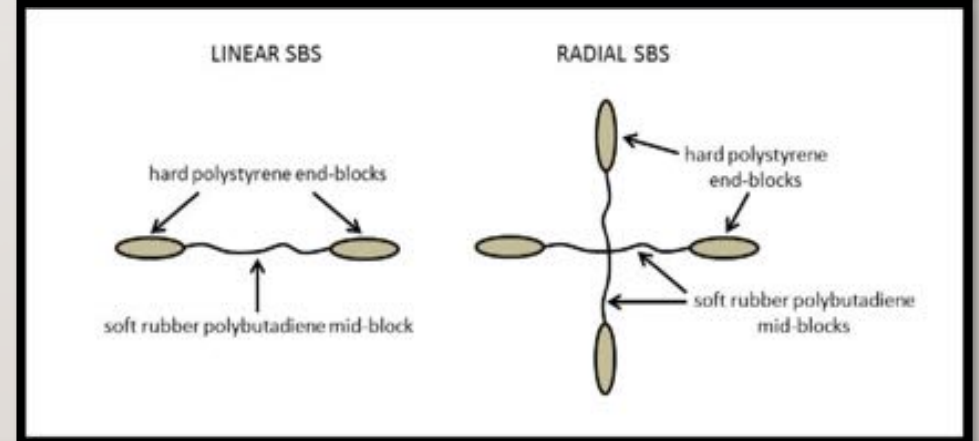
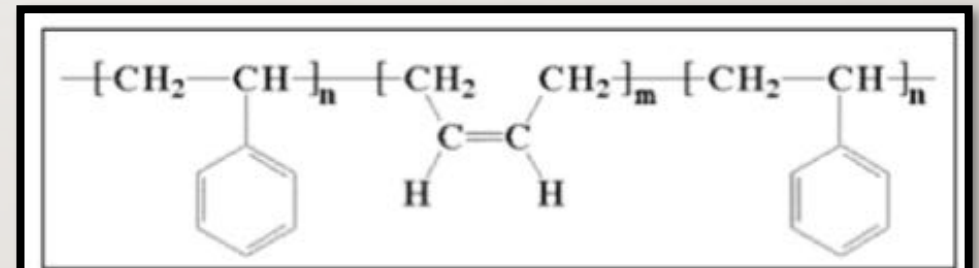


Atactic polypropylene



Isotactic polypropylene

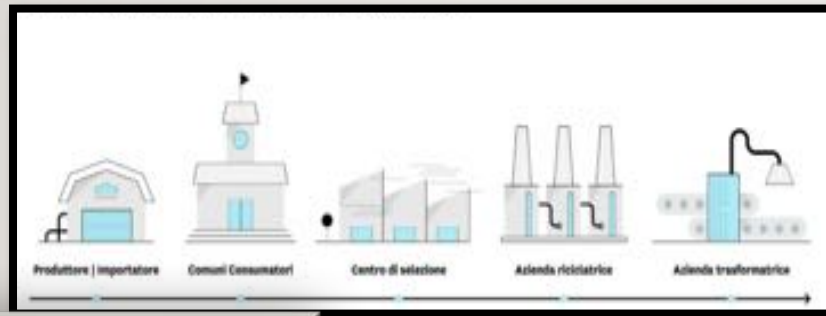
## Mixes SBS



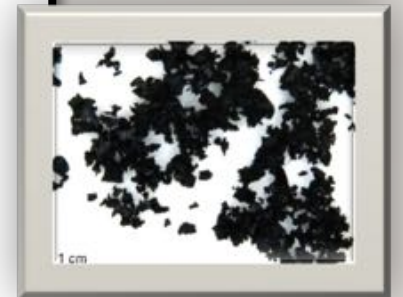
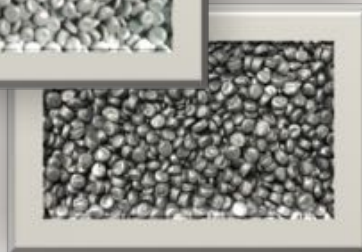


# RECYCLED POLYMERS

## Plastic recycling chain

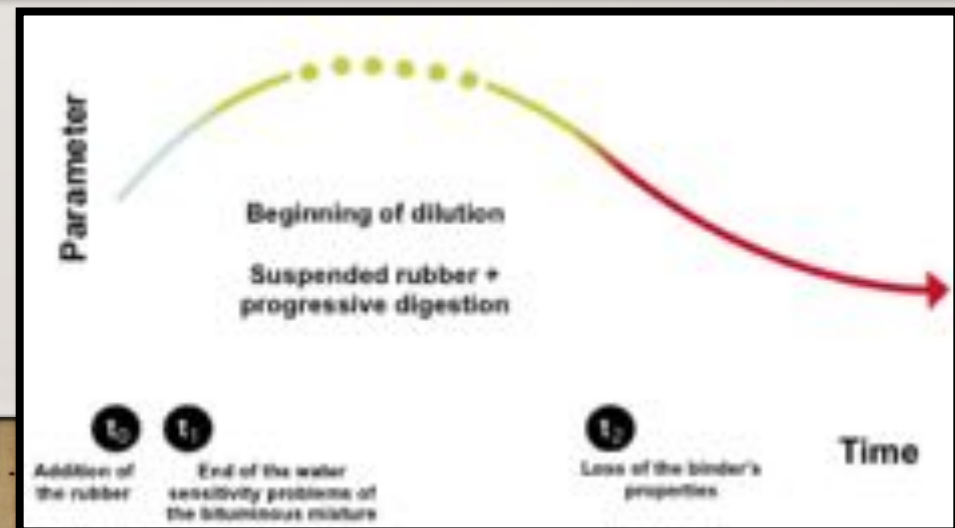
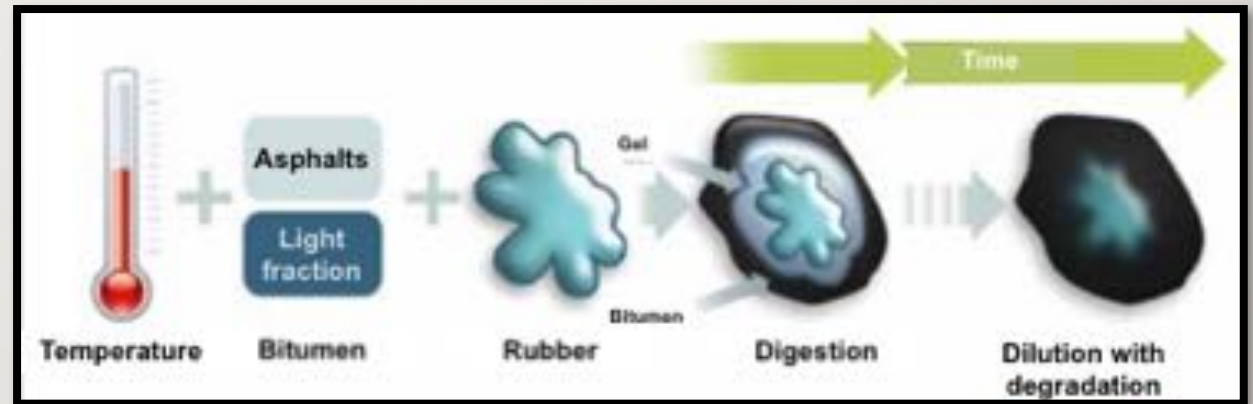


## ELTs recycling chain





# MODIFICATION OF BITUMEN WITH ELTs



# LABORATORY SCALE PRODUCTION

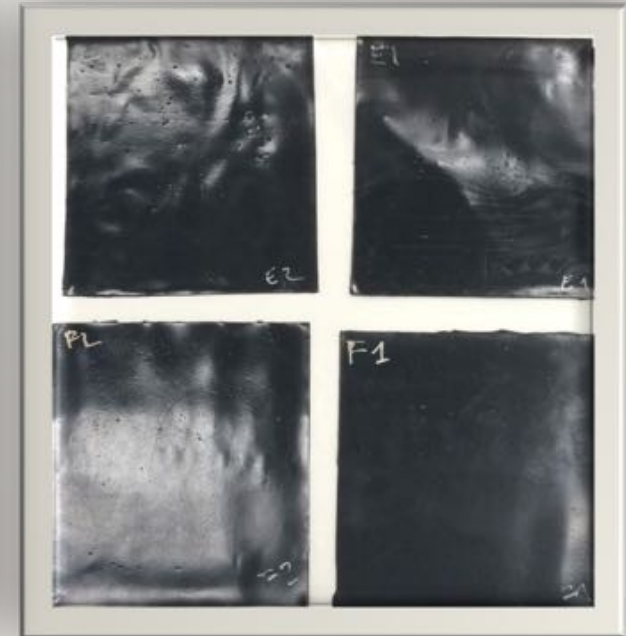
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1. Preparation



2. Casting



3. Final sheath



1. BITUMEN QUALITY TO BE USED TO INCREASE COMPATIBILITY WITH THE ADDITIVE POLYMER
2. ELTs AS A CANDIDATE TO REPLACE ALL OR PART OF SBS

| Formulation                | SBS-0a         | SBS-1a         | SBS-2a         | SBS-3a         | SBS-4a         | SBS-5a         |
|----------------------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Aromatic bitumen 70/100    | 285 g<br>(57%) | 275 g<br>(55%) | 275 g<br>(55%) | 275 g<br>(55%) | 275 g<br>(55%) | 275 g<br>(55%) |
| Blend PE + PP              | 10 g<br>(2%)   | 10 g<br>(2%)   | 10 g<br>(2%)   | 10 g<br>(2%)   | 10 g<br>(2%)   | 10 g<br>(2%)   |
| CaCO <sub>3</sub>          | 175 g<br>(35%) | 175 g<br>(35%) | 175 g<br>(35%) | 175 g<br>(35%) | 175 g<br>(35%) | 175 g<br>(35%) |
| SBS radial                 | 30 g<br>(6%)   | 20 g<br>(4%)   | 20 g<br>(4%)   | 20 g<br>(4%)   | 20 g<br>(4%)   | 20 g<br>(4%)   |
| ELTs T&B 0-200 µm          | -              | 20 g<br>(4%)   | -              | -              | -              | -              |
| ELTs T&B 0-400 µm          | -              | -              | 20 g<br>(4%)   | -              | -              | -              |
| ELTs T&B 400-800 µm        | -              | -              | -              | 20 g<br>(4%)   | -              | -              |
| ELTs automotive 0-400 µm   | -              | -              | -              | -              | 20 g<br>(4%)   | -              |
| ELTs automotive 300-600 µm | -              | -              | -              | -              | -              | 20 g<br>(4%)   |

| Formulation                | SBS-0b         | SBS-1b         | SBS-2b         | SBS-3b         | SBS-4b         | SBS-5b         |
|----------------------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Bitumen API 160/220        | 285 g<br>(57%) | 275 g<br>(55%) | 275 g<br>(55%) | 275 g<br>(55%) | 275 g<br>(55%) | 275 g<br>(55%) |
| Blend PE + PP              | 10 g<br>(2%)   | 10 g<br>(2%)   | 10 g<br>(2%)   | 10 g<br>(2%)   | 10 g<br>(2%)   | 10 g<br>(2%)   |
| CaCO <sub>3</sub>          | 175 g<br>(35%) | 175 g<br>(35%) | 175 g<br>(35%) | 175 g<br>(35%) | 175 g<br>(35%) | 175 g<br>(35%) |
| SBS radial                 | 30 g<br>(6%)   | 20 g<br>(4%)   | 20 g<br>(4%)   | 20 g<br>(4%)   | 20 g<br>(4%)   | 20 g<br>(4%)   |
| ELTs T&B 0-200 µm          | -              | 20 g<br>(4%)   | -              | -              | -              | -              |
| ELTs T&B 0-400 µm          | -              | -              | 20 g<br>(4%)   | -              | -              | -              |
| ELTs T&B 400-800 µm        | -              | -              | -              | 20 g<br>(4%)   | -              | -              |
| ELTs automotive 0-400 µm   | -              | -              | -              | -              | 20 g<br>(4%)   | -              |
| ELTs automotive 300-600 µm | -              | -              | -              | -              | -              | 20 g<br>(4%)   |

# EVALUATION OF THE RHEOLOGICAL VALUES OF THE DIFFERENT COMPOUNDS

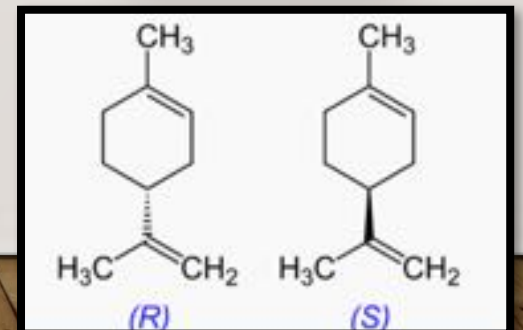
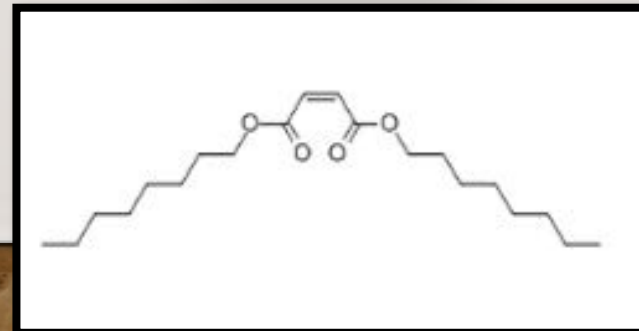
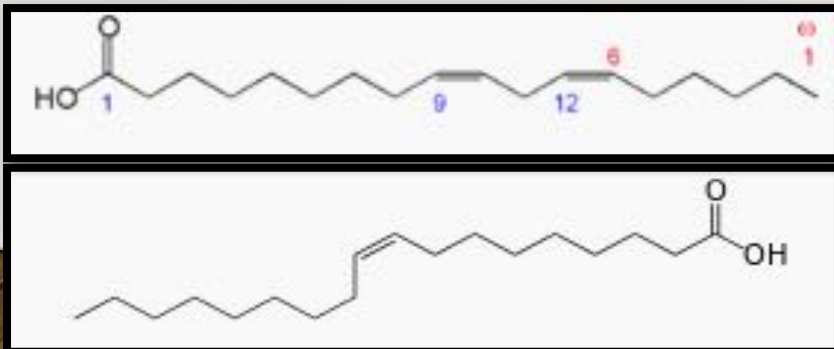
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| Property                        |       |       |       |       |       |       |
|---------------------------------|-------|-------|-------|-------|-------|-------|
| Cold bend (°C)                  | -10   | -10   | -7,5  | -7,5  | -10   | -7,5  |
| Penetration 100g@60°C (dmm)     | 110   | 136   | 135   | 145   | 145   | 160   |
| Ring & Ball (°C)                | 122   | 112   | 112   | 104   | 113   | 98    |
| Viscosity @180°C (cPs)          | 8.250 | 8.500 | 7.250 | 6.000 | 8.250 | 6.500 |
| Spreadability (5 great - 0 bad) | 5     | 4     | 2     | 0     | 2     | 0     |

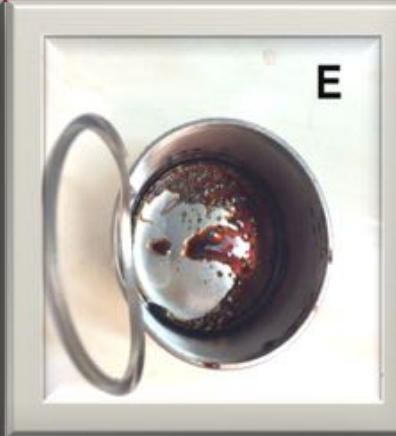
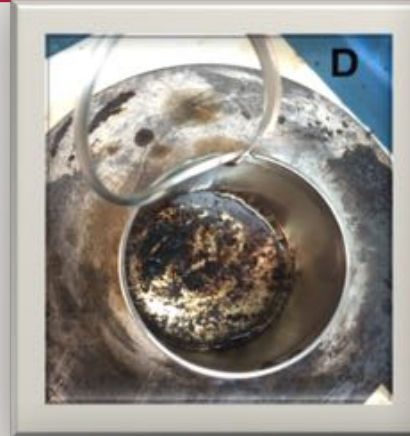
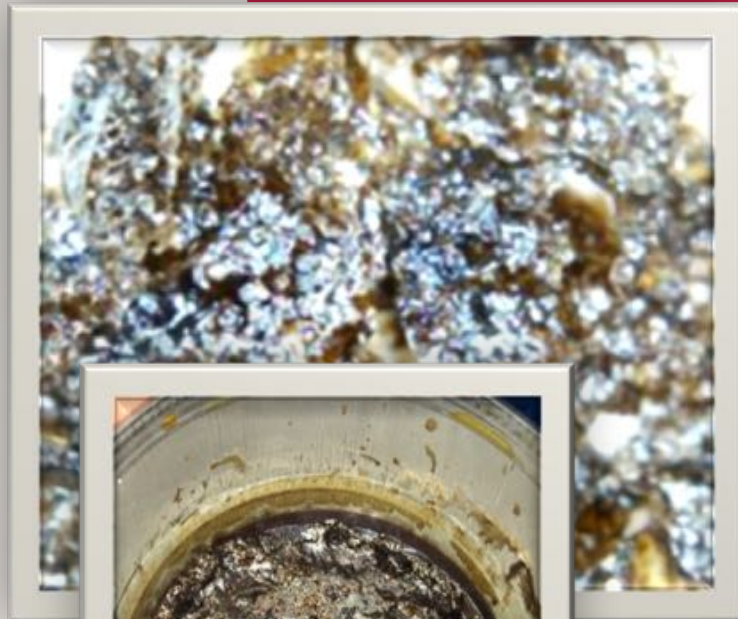
| Property                        |        |        |        |        |        |        |
|---------------------------------|--------|--------|--------|--------|--------|--------|
| Cold bend (°C)                  | -22,5  | -22,5  | -22,5  | -22,5  | -20    | -20    |
| Cold Bend dopo 168h@80 (°C)     | -17,5  | -10    | -10    | -15    | -10    | -10    |
| Delta Cold Bend (°C)            | 5      | 12,5   | 12,5   | 7,5    | 10     | 10     |
| Penetration 100g@60°C (dmm)     | 73     | 90     | 87     | 95     | 91     | 92     |
| Ring & Ball (°C)                | 108    | 109    | 110    | 110    | 113    | 110    |
| Viscosity @180°C (cPs)          | 11.500 | 14.500 | 14.000 | 15.500 | 18.500 | 16.500 |
| Spreadability (5 great - 0 bad) | 5      | 4      | 2      | 0      | 2      | 0      |



# ADDITIVE TO MITIGATE ELTs ODOR



# ANHYDRIFICATION AND DISSOLUTION OF RESIDUE



- Glycerol** was added in **different dosages** for complete dissolution:
- 50% solid - 50% glycerine before heating (D)
  - 50% solid - 50% glycerine heating start (E)
  - 33% solid - 66% glycerine (F)
  - 25% solid - 75% glycerine (G)
  - 20% solid - 80% glycerine (H)



# CONCLUSIONS

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- PFU as a substitute for the SBS;
- WVO dried as best odorigenous additive;
- Bitumen with high % malteni;
- Circular economy;
- Future developments

# ACKNOWLEDGEMENTS

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**MOPI s.r.l.**

- Doc. Giovanni Nicola Vitticano
- Dr. Camillo Cardelli
- Dr. Marco Badalassi
- Dr. Angela Cardelli
- Dr. Francesco Criscitiello
- Prof. Andrea Pucci



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