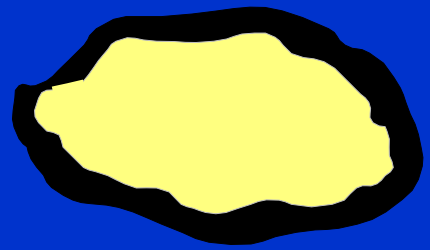
Adhesion and active adhesion



- Adhesion:
  "The process of forming chemical bond between the asphalt film and the aggregate surface"

- Active adhesion:
  "Coating and formation of chemical bond in the presence of water"

General Asphalt Composition

Mixture of Hydrocarbons

Asphaltenes : polar condensed aromatics MW 1000-100 000 (5-25%)

Maltenes

Resins : polar aromatics MW 500-50 000 (15-30%)

Aromatics: non-polar aromatics MW 200-3000 (40-65%)

Saturates: aliphatic hydrocarbons and alkyl substituted cyclics MW 200-5000 (5-20%)

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Acid value and Base value of asphalts

	Acid value (mg KOH/g)	***Base value (mg KOH/g)***
Naphthenic bitumen (Asphalt)	***1.5 to 5***	***0 to 1***
Paraffinic bitumen (Asphalt)	***0 to 1***	***0 to 1***

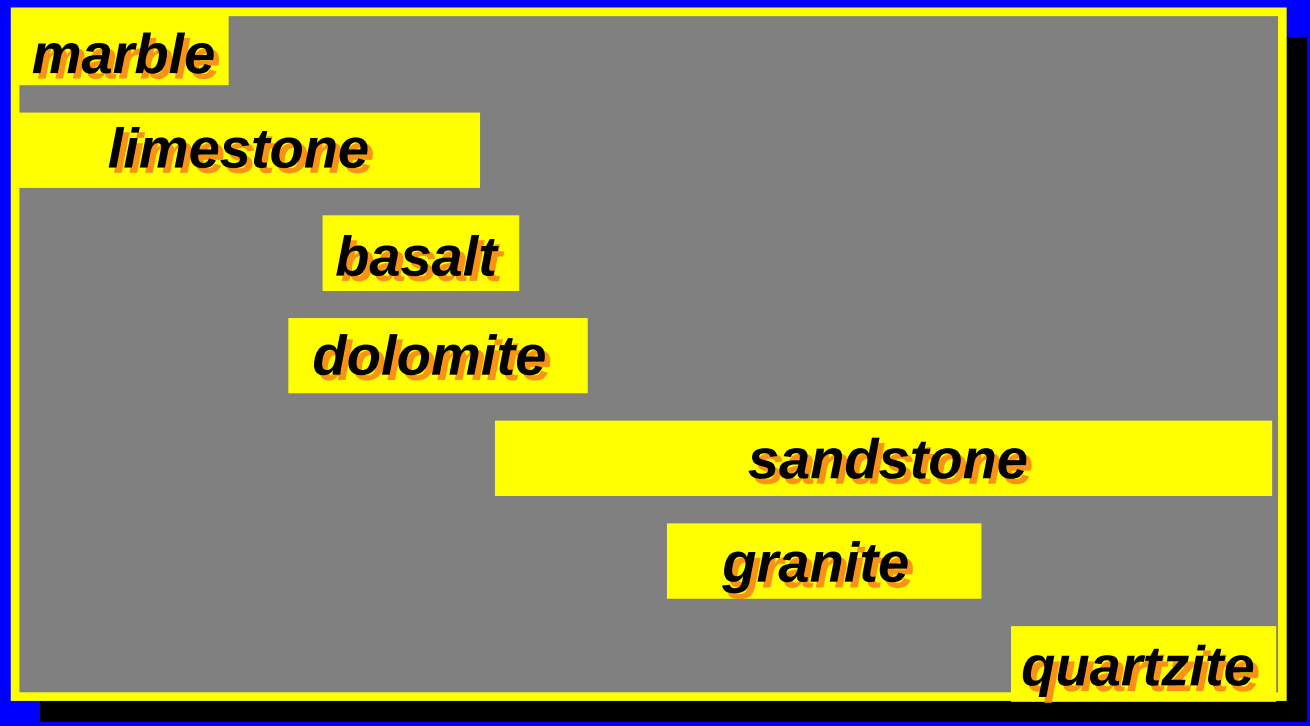
Morgan, P., Mulder, A., The Shell Bitumen Industrial Handbook, p 86-88, 1995

Acidic compounds and basic compounds in asphalt

In naphthenic type asphalts there is a net excess of acid compounds

In general the concentration of basic compounds is low

Chemical Nature of Road Aggregates



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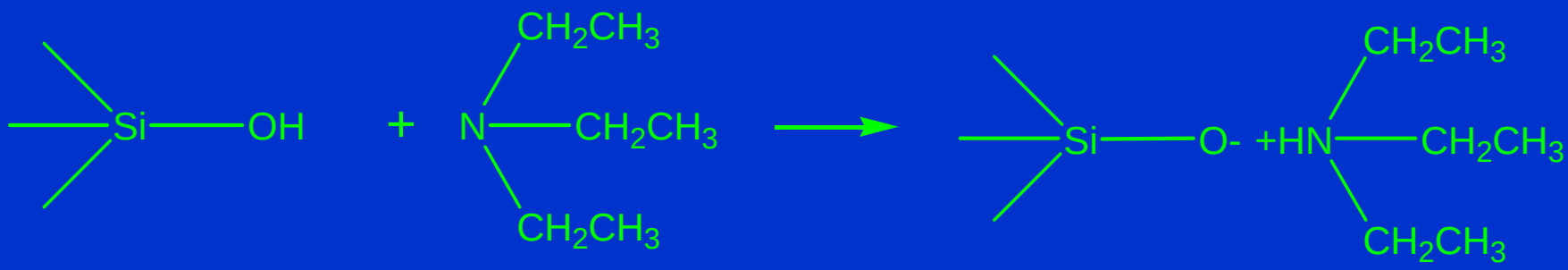
Evidence for acidic surfaces on siliceous aggregates



Silica, Triethylamine compound

Stable >900^{o}F in Vacuum

Titova et. al., Langmuir. 1987, **3**, 960

Aggregate and Asphalt Properties

Aggregate	Surface Properties	Asphalt Properties
Quartzite	Acidic	**Basic Ingredients** usually present in lesser amounts
Granite	Acidic	
Sandstone	Acidic	
Limestone	Alkaline	**Acidic Ingredients**

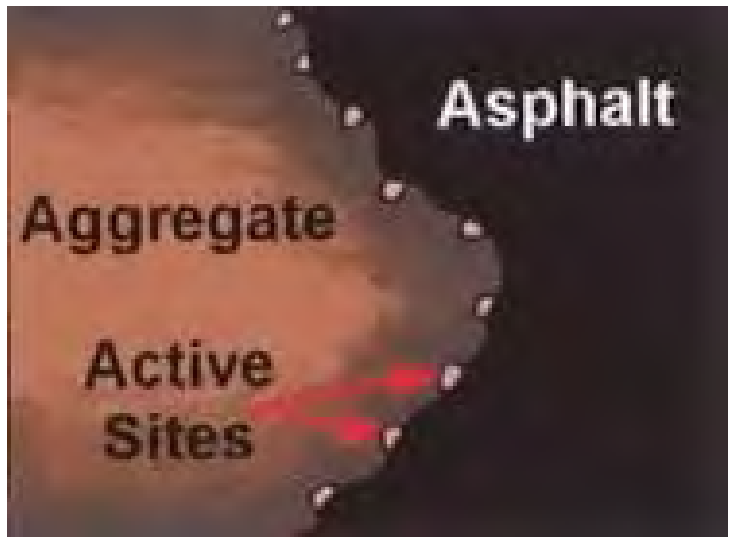
Usually there is a net excess of acidic organic compounds compared to basic organic compounds in Naphthenic asphalts

Stripping in asphalt pavements

Coating without chemical bonding

Moist Aggregate

Dry Aggregate



Osmosis of water through asphalt

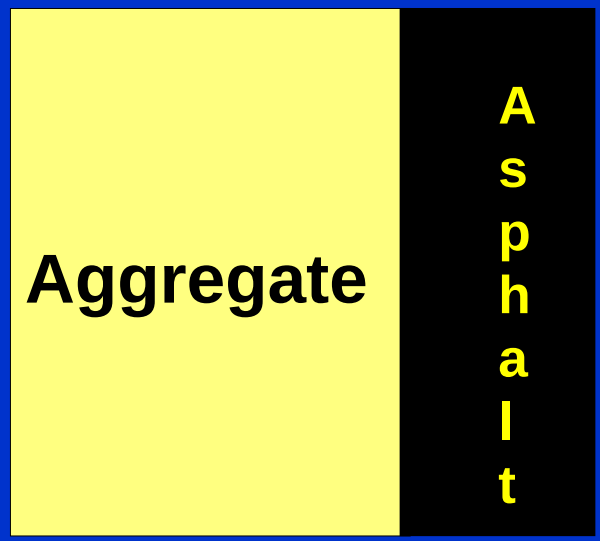
- *Film thickness*
- *Viscosity*
- *Pressure*
- *Composition of asphalt*

Morgan, P., Mulder, A., The Shell Bitumen Industrial Handbook, 1995

Stripping

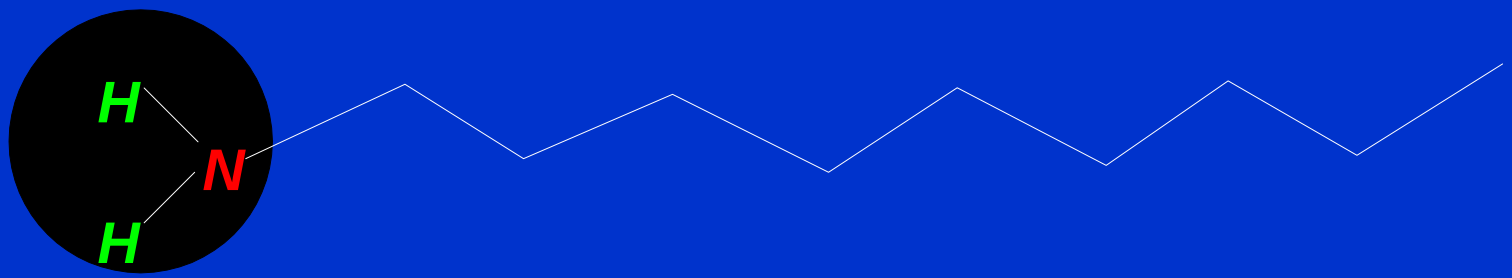

Static immersion test at 60°C
Nynas B 180

Possible ways to improve Surface interaction (adhesion)



Interaction of acidic aggregates and asphalt with alkaline amine components

$$\text{--}SiOH + RNH_2 \rightarrow \text{--}SiO^- RN^+H_3$$



Polar End Group

Non-Polar Hydrocarbon Chain

Asphalt Aggregate Interaction

- *All discussions about surface interactions*
- *Stripping tests*
  - *What are we measuring?*

Stripping tests

- *Boiling Water - ASTM D3625*
- *Static-Immersion - AASHTO T182 or ASTM D1664*


Static immersion test at 60°C
Nynas B 180

Other Tests

- *Modified Lottman - AASHTO T283 or ASTM D4867*
- *Georgia Wheel Rutting Device*
- *Hamburg Wheel Rutting Device*

Important test methods for Hot-mix
And Possible properties evaluatedby various tests

Test methods	***Observed properties***
Boil test, Static immersion	*Surface interaction between aggregate and asphalt (Adhesion)*
Lottman type tests And Wheel tracking tests	*Surface interaction (Adhesion)* + *Hardening effect of the asphalt and mix (cohesion?)*

Some points

1. *Asphalt Aggregate interaction (Adhesion and Stripping) depends on the type of aggregate and asphalt composition*

2. *There is a lack of interaction (Adhesion) in most mixes and can be improved by proper treatment*

3. *Adhesion and stripping is a surface phenomenon*

4. *May be a combination of stripping tests should be used to evaluate both surface interactions and the mix properties (cohesion?)*