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Analysis of bitumen rejuvenation using FTIR-ATR

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Date: 24-Nov-2016

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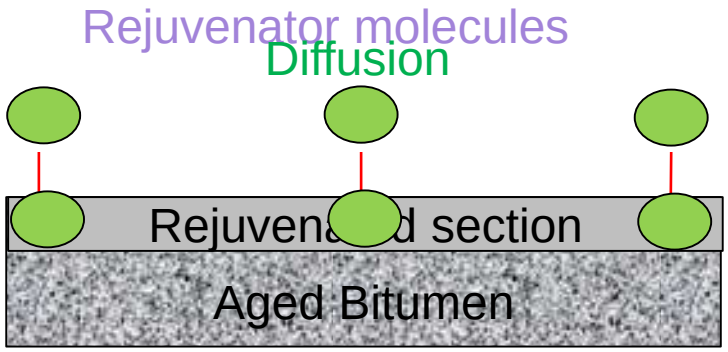
Background

- Rejuvenation depends on the phenomena of movement of rejuvenator molecules into bitumen called as **diffusion**

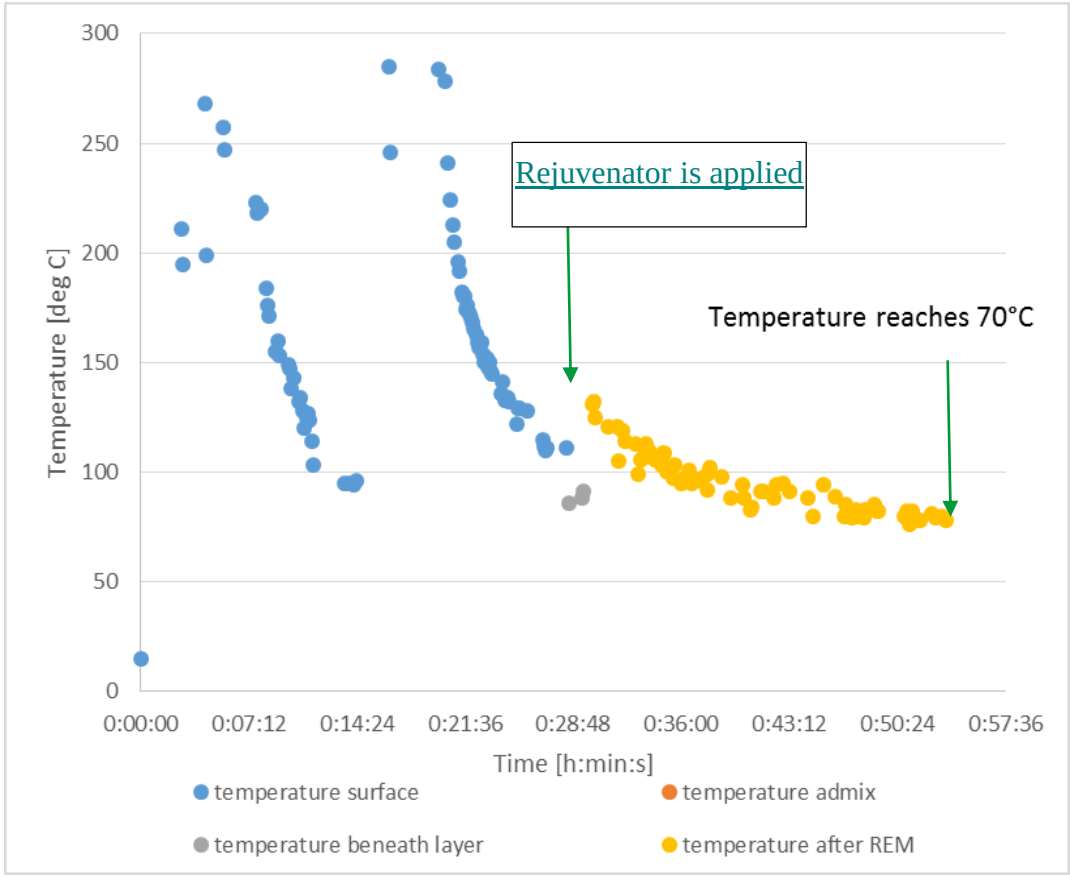
- Factors affecting diffusion are:
  - Temperature
  - Molecular mobility
  - Individual viscosities
  - Compatibility of materials



Research area/problems

- **Is the rejuvenation proceeding during the REMIX process**

- Literature studies 120^{0}C →in-plant heating
- Low temperature rejuvenation → diffusion in piles
- REM specific field results
  - Bitumen and rejuvenator remains at above 70^{0}C for approx. 30 mins



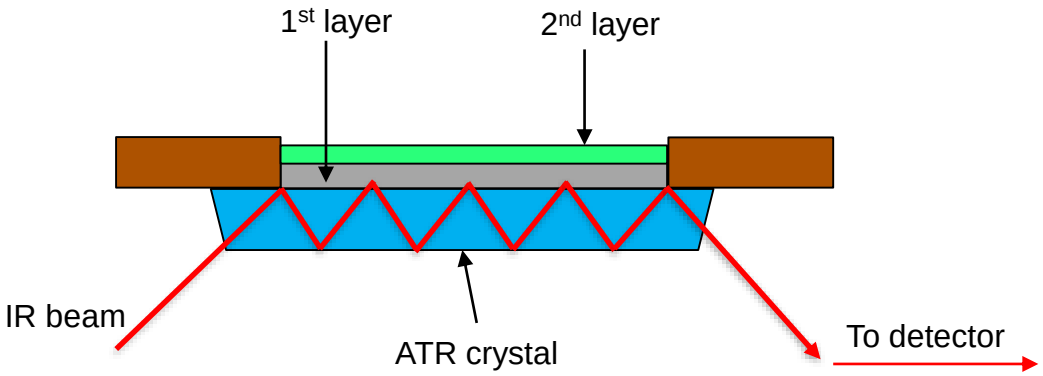
Research aims

- This research was focused to examine the influence of following factors on rejuvenation process:

1. **Binders softness**
2. **Rejuvenator type and viscosity**
3. **Temperature**
4. **Time**

Technique used

- Fourier transform infrared spectroscopy (FTIR) along with attenuated total reflectance (ATR)
- How FTIR-ATR is applicable in this case?
  - Principle of FTIR-ATR is;



Technique used

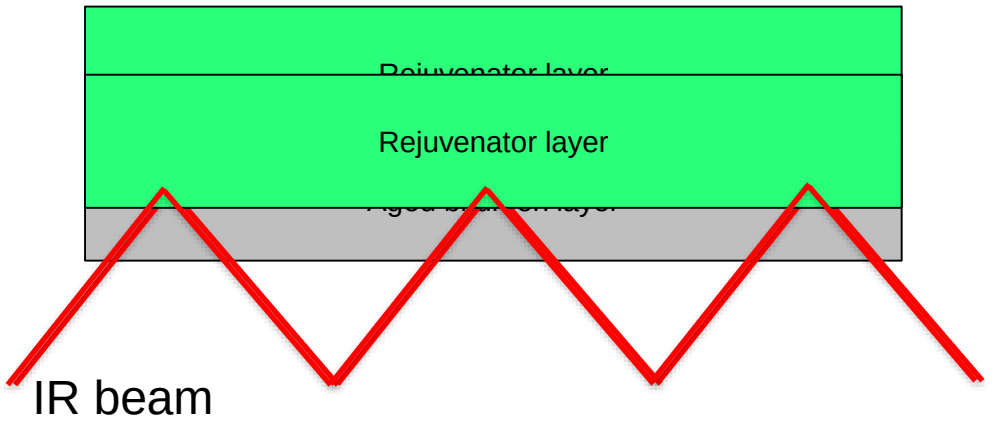
Due to ageing;

- Certain functional groups appeared in bitumen spectra
  - Carbonyl, aromatics and sulfoxide
- These can be identified by FTIR-ATR spectrum

Upon rejuvenation;

- Rejuvenator molecules diffuse into bitumen
- Concentration of functional groups altered
- Due to change in concentration, absorbance also changes
- This change in absorbance appears in FTIR-ATR spectra
- This change in spectrum indicates rejuvenation

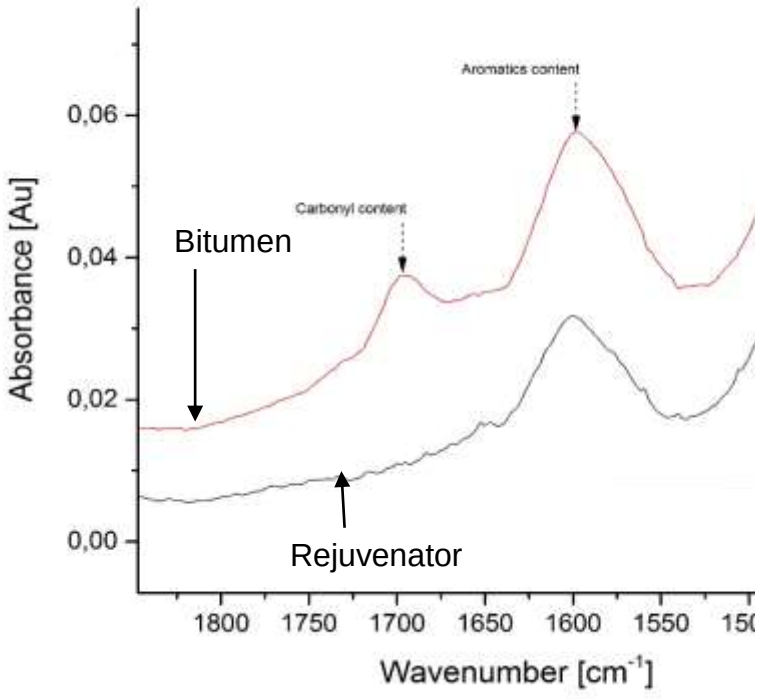
Note: *In case of oil based rejuvenator, different ranges were analyzed*



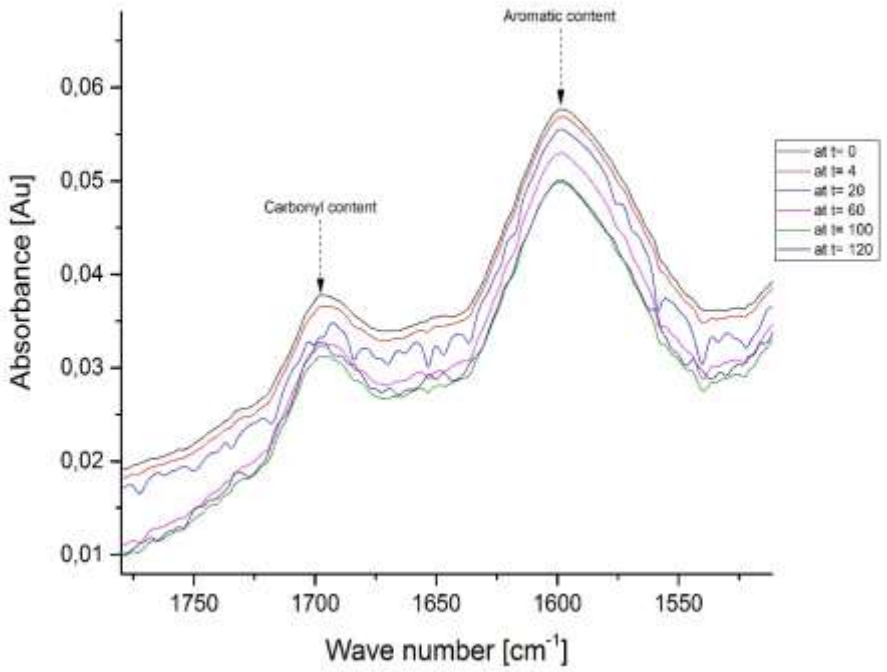
Technique used

Change in absorbance of carbonyl and aromatic regimes

Before rejuvenation



After rejuvenation



Materials

- Aged bitumen; 1R (Area 1) and 70/100

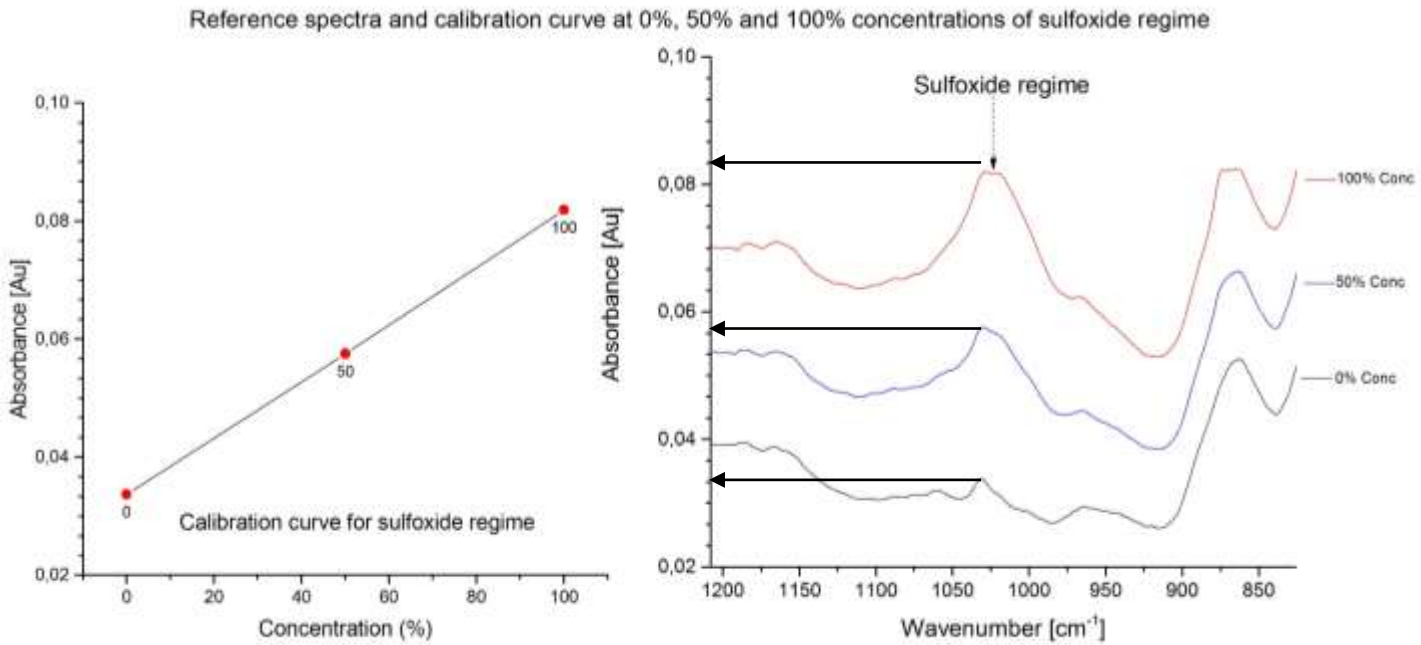
- Rejuvenator; R1 and R4 (softer grade bitumen)
  R2 and R3 (Bio and oil based rejuvenators)

- Measuring temperatures; 40˚C, 60 ˚C, and 90 ˚C

		Bitumen used	Viscosities of Rejuvenators applied (Pa)			
Pen (dmm)	**S.P (˚C)**		**R1 650/900**	**R2**	**R3**	**R4 V1500**
22	65	1R	6,196	0,021	0,033	1,209
76	48,8	70/100	6,196	0,021	0,033	1,209

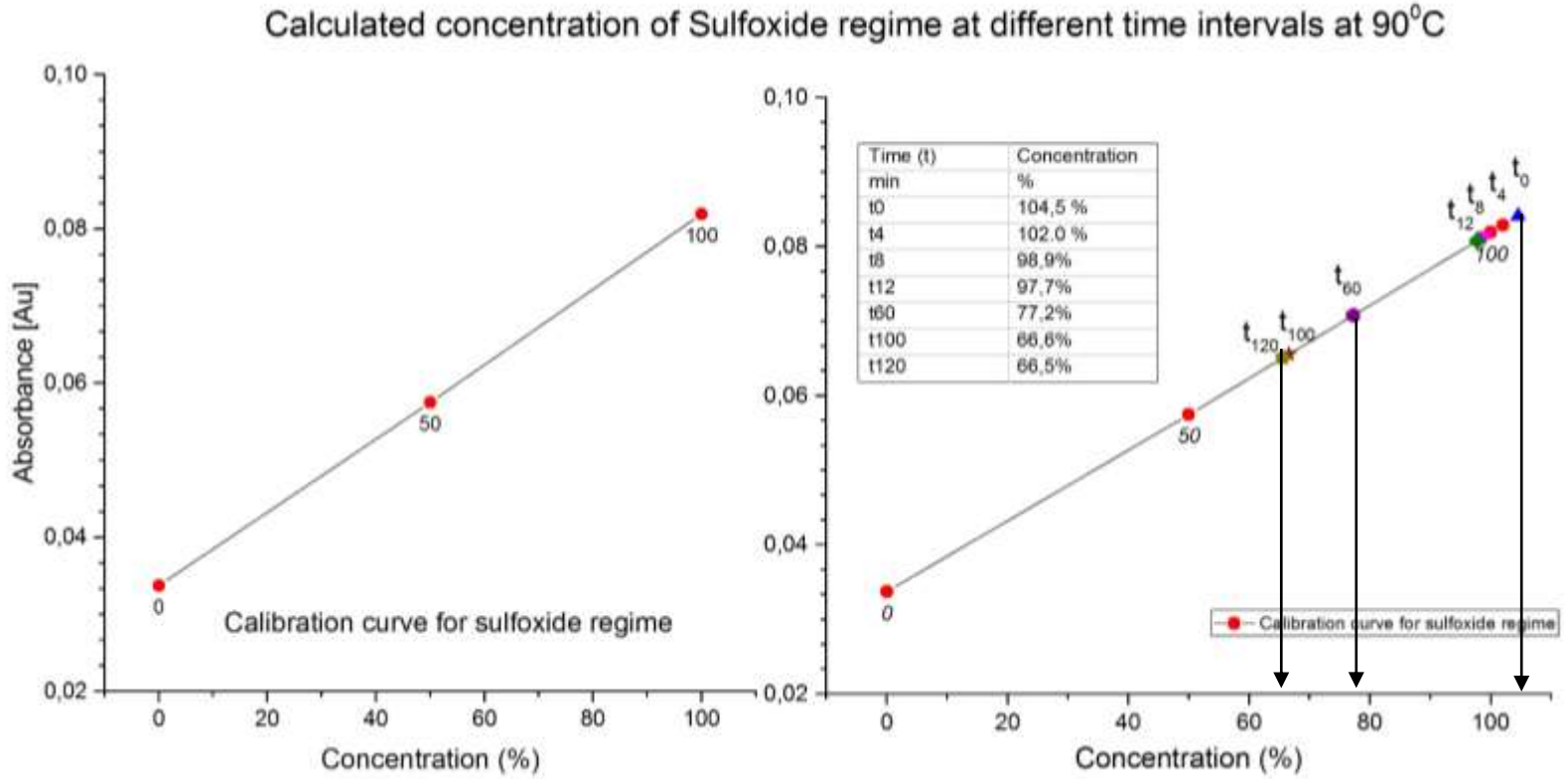
Calculations

- For referencing:
  - Calibration curves of known concentrations, 0%, 50% and 100% Example:



Calculations

- Calculated concentrations at 90^0C
  - According to Beer-Lambert law ; $A \propto c$
  - Higher the concentration, higher is the absorbance



Results

- Concentrations of marker peaks were calculated at 40^0C, 60^0C and 90^0C

- Bitumen 1R and 70/100 were compared against all rejuvenators, R1, R2, R3 and R4

- In case of R2, concentration at different peaks were calculated

Results

- Average level of rejuvenation in bitumen 1R (Area 1) rejuvenated by 650/900

Time span	Level of rejuvenation at 40^{0}C	Level of rejuvenation at 60^{0}C	Level of rejuvenation at 90^{0}C
min	%	%	%
0	0	0	0
20	-	0,36	8
40	-	1,25	13
60	-	0,5	18,7
80	-	1	27,8
100	-	1	27,1
120	-	2,2	27,0

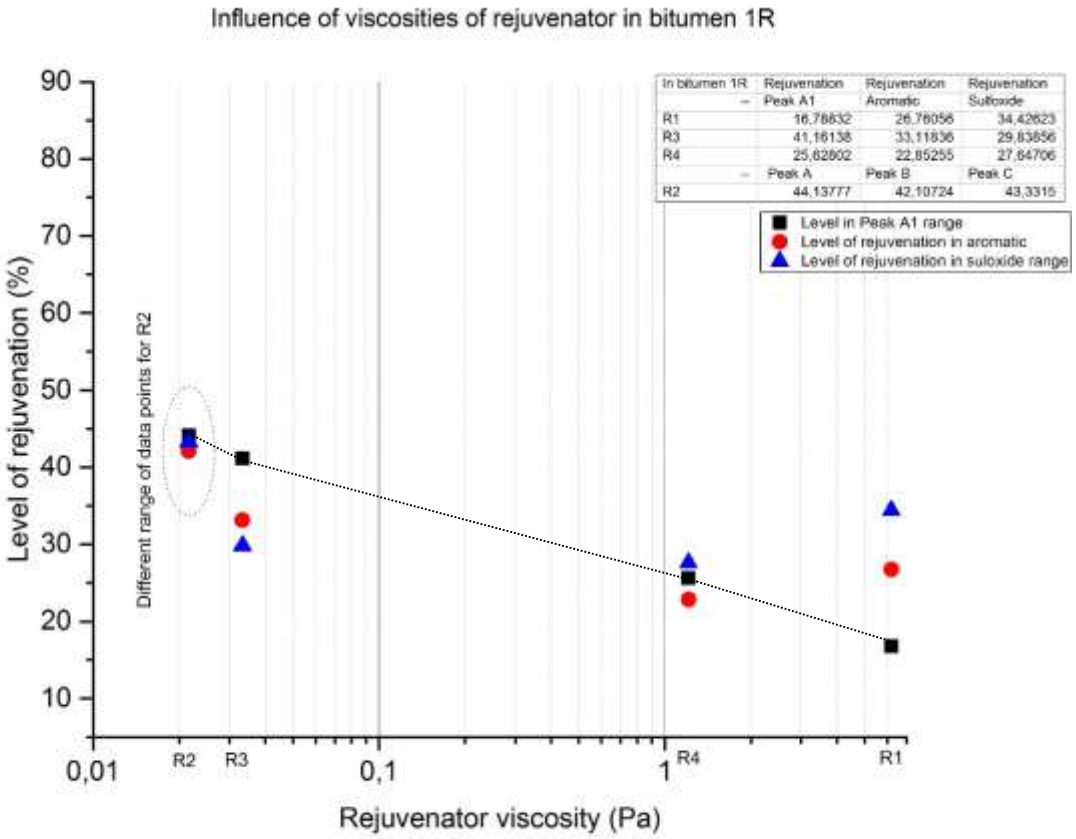
Results

- Average level of rejuvenation in bitumen 1R (Area 1) rejuvenated by V1500

Time span	Level of rejuvenation at 40^{0}C	Level of rejuvenation at 60^{0}C	Level of rejuvenation at 90^{0}C
min	%	%	%
0	0	0	0
20	-	0,35	6,8
40	-	0,17	9,4
60	-	0,01	13,2
80	-	0,1	15,4
100	-	0,9	20,6
120	-	0,1	24,7

Results

- Influence of viscosity on rejuvenation of 1R



Results

- Influence of Bitumen softening

Bitumen	Softening point	Level of rejuvenation with R1(650/900)		
	^{0}C	40^{0}C	60^{0}C	90^{0}C
70/100	48,8	-	3.3%	39%
1R	65	-	2%	26%

Conclusion

- Rejuvenation was found in all cases to proceed at higher temperature (90^0C)
- Rejuvenation occurs above softening point of bitumen
- Softer rejuvenator was found more effective in rejuvenation

Suggestions

- If we want to allow for maximum rejuvenation within the 30 minutes after REMIX works
  - Choose an appropriate **temperature** above the **Softening Point** of old bitumen
  - Increasing the level of rejuvenation may be achieved by a choice of a softer rejuvenator

Questions