Pipeline impurities and specifications

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Long experience with CO_2 transport !

- CO_2 injection for EOR > 40 years (USA)
- More than 100 installations, more than 5000 km pipeline
- **C-steel**: Good experience with clean and dry CO_2
- Reported corrosion when water accumulates
- CRA: ”Wet” CO_2, Sleipner, short distance
- Thousands of papers/corrosion studies for pCO_2 < 20 bar
  - Relative few studies for pCO_2 > 50 bar and CO_2 with impurities

Why are we spending a lot of resources on research on CO_2 specifications?

What are the new corrosion and materials challenges?

CCS CO_2 transport challenges vs. previous CO_2 transport experiences

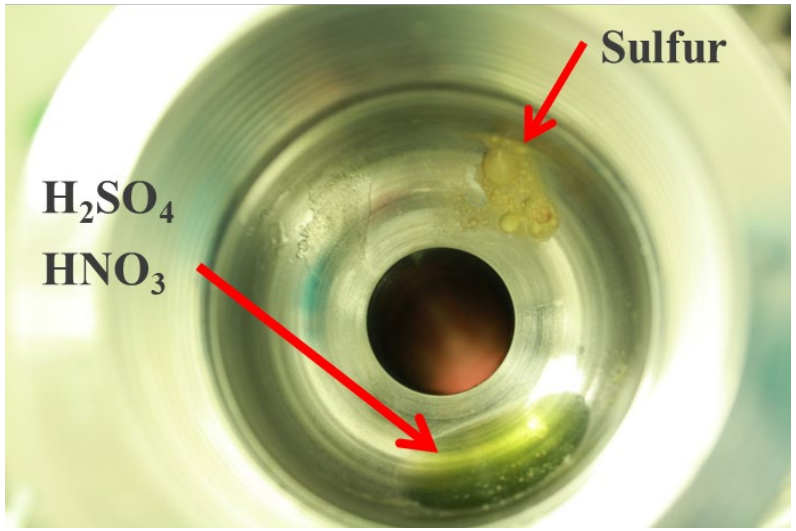
- New impurities: H_2O, H_2S, O_2, SOx and NOx, CO, NH_3, +++
  - When will cross chemical reaction take place?
  - When will aqueous phases form?
  - When will corrosion become a problem?

$$2\ H_2S + O_2 \rightarrow S_x + 2\ H_2O$$

$$4\ NO_2 + O_2 + 2\ H_2O \rightarrow 4\ HNO_3$$

$$SO_2 + H_2O + \tfrac{1}{2}\ O_2 \rightarrow H_2SO_4$$

- Complex network, many point sources
  - mixing, compatibility, monitoring
- Reuse of existing oil and gas infrastructure



How much and which types of impurities can be accepted in the CO_2 stream ?

Comp ppm-mol	US pipelines <2007	Dynamis 2007	Goldeneye/ Peterhead 2014 (2016)	CarbonNet project 2016	Northern Lights 2019	NETL design 2019	Porthos 2021	TES/OGE 2022	Aramis Ship 2023	Aramis Pipeline 2023	AMPP Tentative 2023
H_2O	-630	500	50	100	30	500	70	30	30	70	100
H_2S	-9000	200	0.5	100	9	100	5	10	5	5	10
CO	-1000	2000	10	900-5000	100	35	750	100	1200	750	1000
O_2	-70	<40000	1 (5)	20000-50000	10	10	40	30	10	40	20
SOx (total S)		100	10	250-2500	10	100	20	30	10	20	20/60
NOx		100	10	200-2000	10	100	5	1	1.5	2.5	2.5/10
MeOH							620		40	620	
NH3						50	3	10	10	3	

NETL (National Energy Technology Laboratory)
AMPP: Association for Materials Protection and Performance

- Generic specifications,
- Project specific specifications

- Concentrations stricter with time
- No model can predict the limits (OLI)
- ISO standard. No recommended limits
- Lack of experimental data
- Ongoing JIP projects: IFE-KDC IV, DnV, Ohio,..

Acceptable CO_2 specifications

- A CO_2 specification that does not give a **corrosive phases**
- **The acceptable CO_2 composition will be project specific.**
- **NO_2 a "bottle neck":** The presence of NO_2 and the combination of NO_2 , SO_2 ,H_2S and O_2 promote formation of corrosive aqueous phases at very low water concentration
- Optimization. **Modelling and testing/verification required**

Which part of the CCS chain constrains the CO_2 stream composition?