The stored SMC ammonia
- a status report

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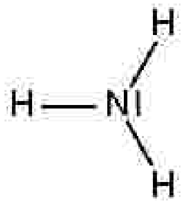
Outline

- Some facts about ammonia
- Reasons for ammonia
- Chemically doped ammonia
- Irradiated ammonia
- ESR spectrum
- NMR signals
- Polarization build up and relaxation
- Summary

Some facts about ammonia

- discovered in 1773 by Priestley
- colorless gas with a pungent smell at room temperature
- can cause explosions with air
- dangerous for your eyes
- suffocating
- maximum allowable concentration (MAC): 20 ml/m³
- density: 0.771 kg/m³ at 193 K
- melting point: 195.75 K
- boiling point: 239.75 K
- Haber-Bosch-Process



Reasons for ammonia

- Ammonia (NH_3) contains 17.6 % (by weigth) of polarizable free protons compared to 13.6 % in butanol.
- The content of polarizable free deuterons in d - ammonia (ND_3) is 30 % compared to 23.8 % in d - butanol and 19 % in d - propandiol.
- The radicals are stable in liquid nitrogen for years.
- Extremely good polarization resistance to radiation damage.

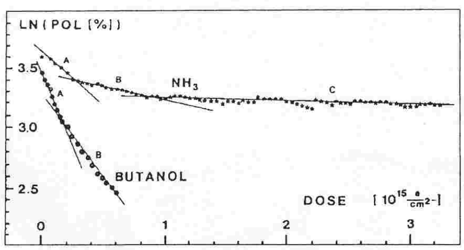


Fig. 3. Radiation damage of butanol and NH_3 (log scale).

- The annealing process is at a lower temperature (~ 77 K) than for a butanol sample (110 K).

Chemically doped ammonia

- solidification process ist more complicated and time consuming (in comparison with alcohol and diol targets)

1. Liquefy in a bath of methanol dry ice at 193 K
2. During condensation chemical dopants can be dissolved and mixed
   e. g.: Cr(V) glycerol complexes or sodium
3. Frozen beads can be made by
   - dripping the ammonia into liquid nitrogen (opaque white)
   - freezing to a solid block (t > 1 h) and crush it under liquid nitrogen conditions into small pieces.

Disadvantages: - bad mechanical stability, because of voids and cracks
- filling factor of a target volume is 55 % (60 % butanol)

Solution: dripping the ammonia into liquid isopentane (clear beads)

Irradiated Ammonia

There exist two different irradiation techniques:

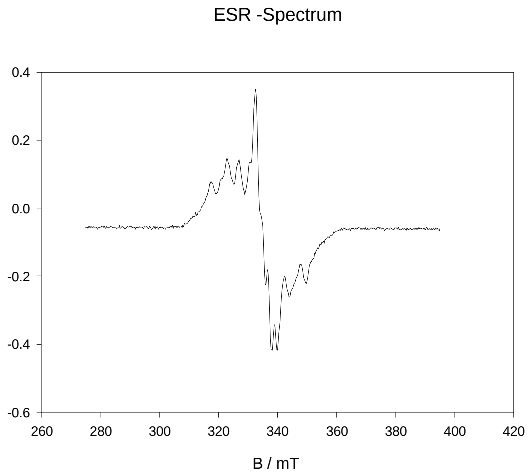
- High temperature irradiation at 80 - 90 K
  - Ammonia can be irradiated somewhere, stored under liquid nitrogen and transported to the experimental area (beam).
  - Suitable in combination with electron and proton beams.
  - Also useable with low-intensity secondary beams, such as muons, pions, kaons or photons.

- Low temperature irradiation at ~ 1 K
  - The radicals are produced during the experiment.
  - Only suitable in combination with high-intensity beams of ionizing particles like protons or electrons.

→ First visible result of an irradiation is the violet color of the material.

ESR spectrum of irradiated ammonia

Sample of SMC material

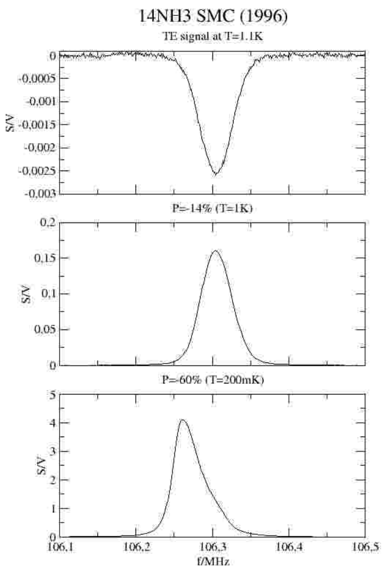


ESR results
- There are still radicals
- No change in structure of the ESR line

$\rightarrow$ No change of radicals

X-band ESR spectrometer:
- B_0 = 340 mT
- μw-frequency = 9.5 GHz
- Cooled with liquid nitrogen

NMR signals of ammonia



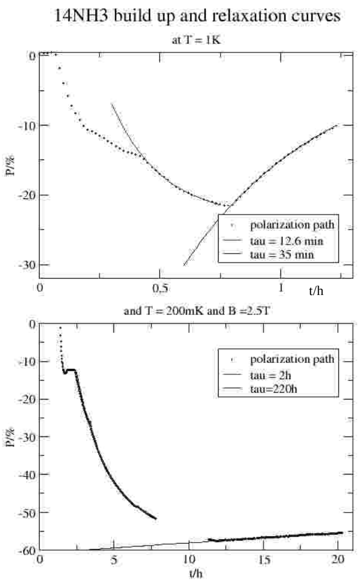
Proton polarization

TE - Signal
- T = 1.1 K
- B = 2.5 T

^{4}He - cryostat
- T = 1 K
- B = 2.5 T
- P = -14 %

Dilution - cryostat
- T = 200 mK
- B = 2.5 T
- P = -60 %

Polarization build up and relaxation



Measured at 2 different temperatures:
- T = 1 K and B = 2,5 T
- T = 200 mK and B = 2,5 T

We reached a polarization of
- -22 % after 45 min
- - 57% after 12 h

Relaxation time:
- t = 35 min at 1 K
- t = 220 h at 200 mK

Time	T
1 day	8 min
5 weeks	10 min
1,5 years	23 min
9 years	35 min

comparable to older measurements

Polarization limited by
- low cooling power
- low μw - power
- problems with the cryostat

Summary and Outlook

- High number of polarizable protons and deuterons
- Good resistance against radiation damage
- Radicals are stable in liquid nitrogen
- Relaxation time is comparable with older measurements
- It is still possible to polarize the ammonia to the known values
- The „old“ SMC ammonia is still useable

Outlook

- Temperature stability of the radicals