Stability of radicals in irradiated ammonia

D. Buschert, F. Greffrath, J. Heckmann, C. Heß, W. Meyer, P. Pfaff, E. Radtke, G. Reicherz, M. Schiemann

- *Introduction*
- *Results for NH_3*
- *Results for ND_3*
- *Conclusions*

Introduction

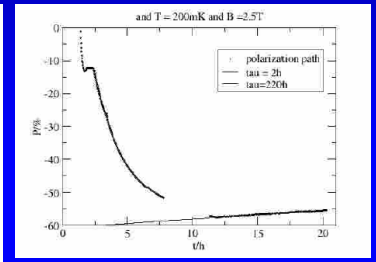
Summary and Outlook

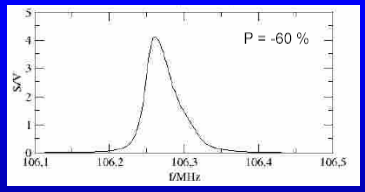
- High number of polarizable protons and deuterons
- Good resistance against radiation damage
- Radicals are stable in liquid nitrogen
- Relaxation time is comparable with older measurements
- It is still possible to polarize the ammonia to the known values
- The „old“ SMC ammonia is still useable

Outlook

- Temperature stability of the radicals

Miltenberg, 03.06.2005 Daniel Buschert



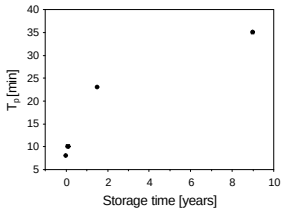


Introduction: previous studies

- *Ammonia already comprehensively studied (W. Meyer et al., PST 1984, Bonn)*
  - *critical temperature of 117 K for NH_3 (loss of violet colour)*
  - *complete loss of violet colour in ND_3 at 134 K*
  - *material became paler after some weeks under LN_2 (→ slow loss of radicals)*
  - *proton relaxation time increases with time of storage ($T_p \sim T_e / N_e$)*

Results in $^{14}NH_3$ at 1 K.

Time after irradiation	P [%]	τ [min]	T_p [min]	N_e [radical spins/ml]
1 day[a)]	31	2	8	1.2×10^{20}
5 weeks[a)]	31	2.5	10	9.6×10^{19}
1.5 years[b)]	35	6.5	23	4.2×10^{19}

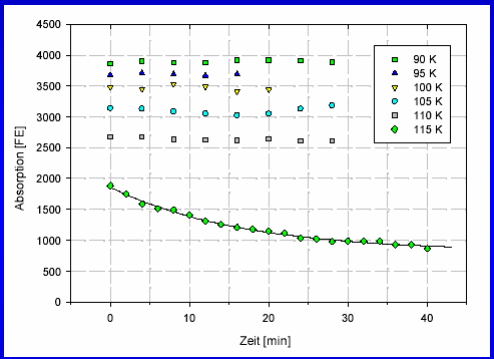


- *NH_3 now is pale, $^{15}ND_3$ still violet*

Temperature stability of irradiated d-butanol

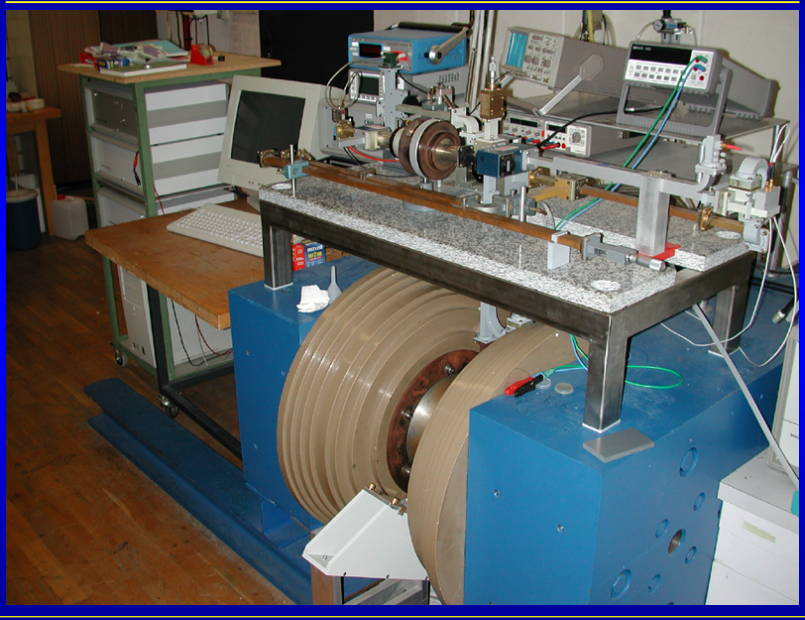
ESR measurements:

- *ESR signal constant below T=115 K*
- *significant decrease at T=115 K (→ J. Harmsen)*

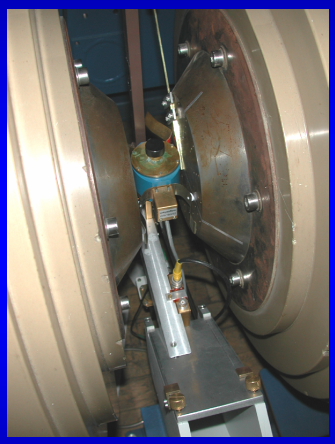


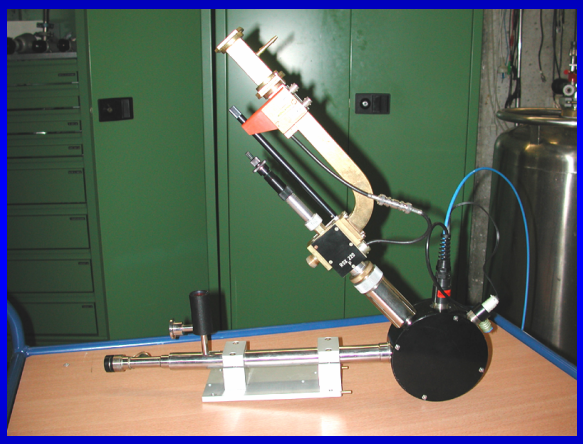
Oxford ESR cryostat used (room temperature → 4 K possible)

X-band spectrometer



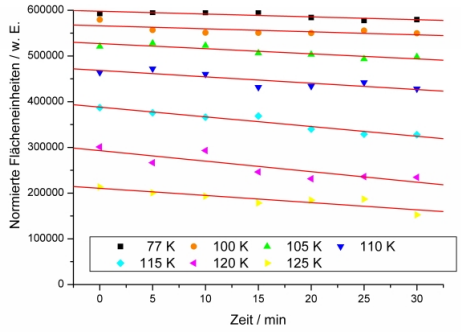
X-band spectrometer





ESR cryostat, operated with ^{4}He, temperature adjustment: +/- 0.1 K

Results: NH_3



From slope of regression:

- loss of radicals starts at 105 K

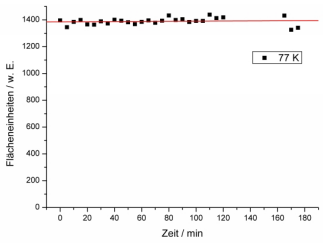
- maximal at 115 – 120 K

Radical loss after 30 mins:

5 % at 110 K

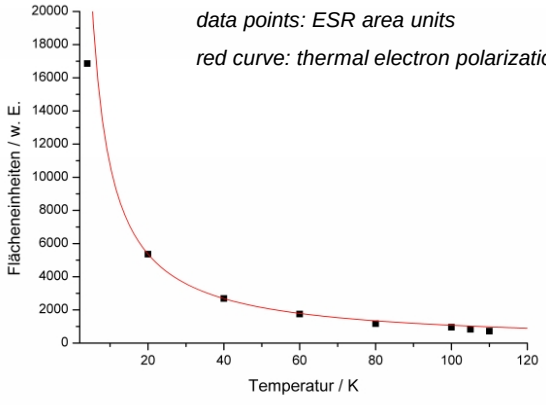
15 % at 115 K

23 % at 120 K



Effect not as clear as in irradiated butanol !

Results: NH_3

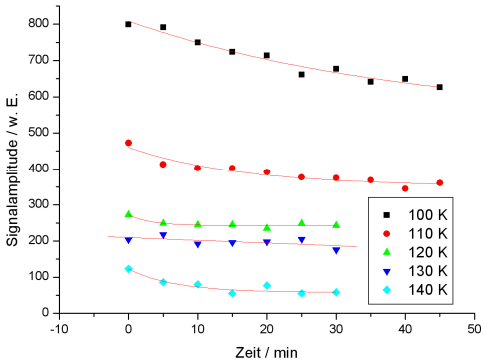


data points: ESR area units

red curve: thermal electron polarization

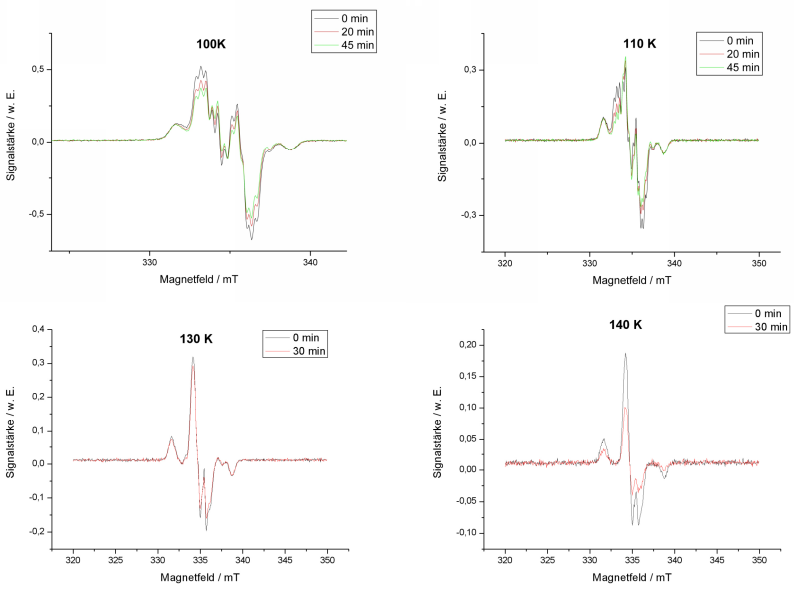
Radical „decay“: small effect above 100 K

Results: ND_3



- *Two steps of radical „decay“ in $^{15}ND_3$:*
  - *around 100 K*
  - *around 140 K*
- *„Decay“ stops between 120 K and 130 K*

Results: ND_3



Conclusions

- **No sharply defined critical temperature in NH_3**
  - *radical „decay“ starts at 105 K*
  - *maximal at 115 K – 120 K (23 % of radicals lost after 30 minutes)*
  - *at 130 K all radicals are gone*
  - *colour center vanishes already at 77 K, DNP relevant center stable*

- **Two steps of radical „decay“ in ND_3**
  - *first step around 100 K*
  - *second step around 140 K*
  - *ESR spectra: two different kinds of radicals*

  - *which center belongs to which „decay“ step (analogous to NH_3)?*

  → *further studies (including $^{14}ND_3$)*