

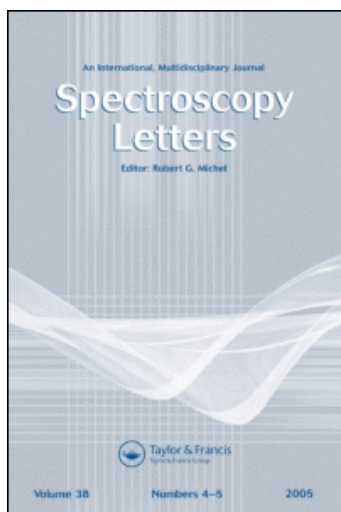
This article was downloaded by:

On: 30 January 2011

Access details: *Access Details: Free Access*

Publisher *Taylor & Francis*

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



## **Spectroscopy Letters**

Publication details, including instructions for authors and subscription information:

<http://www.informaworld.com/smpp/title~content=t713597299>

### **Threefold Phosphorus-Nitrogen Reorientation Barrier in Trichlorophosphazocompounds from $^{35}\text{Cl}$ NQR Data**

I. A. Kjunzel<sup>a</sup>; V. A. Mokeeva<sup>a</sup>; G. B. Soifer<sup>a</sup>; E. S. Kozlov<sup>b</sup>

<sup>a</sup> Perm State University, Perm, U.S.S.R. <sup>b</sup> Institute of Organic Chemistry Academy of Sciences of the Ukraine, Kiev, U.S.S.R.

**To cite this Article** Kjunzel, I. A. , Mokeeva, V. A. , Soifer, G. B. and Kozlov, E. S.(1975) 'Threefold Phosphorus-Nitrogen Reorientation Barrier in Trichlorophosphazocompounds from  $^{35}\text{Cl}$  NQR Data', *Spectroscopy Letters*, 8: 2, 113 – 117

**To link to this Article:** DOI: 10.1080/00387017508067313

**URL:** <http://dx.doi.org/10.1080/00387017508067313>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.informaworld.com/terms-and-conditions-of-access.pdf>

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

THREEFOLD PHOSPHORUS-NITROGEN REORIENTATION  
BARRIER IN TRICHLOROPHOSPHAZOCOMPOUNDS FROM  $^{35}\text{Cl}$  NQR DATA

I.A.Kjunzel, V.A.Mokeeva, and G.B.Soifer  
Perm State University, Perm, U.S.S.R.

E.S.Kozlov  
Institute of Organic Chemistry  
Academy of Sciences of the Ukraine,  
Kiev, U.S.S.R.

In the present paper we describe the  $^{35}\text{Cl}$  NQR investigation of  $\text{PCl}_3$ -reorientations in the molecules of three trichlorophosphazocompounds,  $\text{Cl}_3\text{P}=\text{NCCL}(\text{CCl}_3)_2$  (I),  $\text{Cl}_3\text{P}=\text{NP}(\text{O})(\text{CCl}_3)_2$  (II),  $\text{Cl}_3\text{P}=\text{NCOCF}_3$  (III). In order to elucidate the quantitative parameters of the reorientational motion we have used (unlike<sup>I</sup>) the temperature dependence of the quadrupole spin-lattice relaxation time  $T_1$  which is very sensitive to a molecular dynamics<sup>2,3</sup>.

In the temperature range  $77 \pm 180^\circ\text{K}$  an exponential decrease of  $T_1$ , an equalization of its values for the different chlorine nuclei of the  $\text{PCl}_3$  group and fading out of the  $^{35}\text{Cl}$  NQR signals of this group are observed. Typical experimental data for III are shown in the Figure. They confirm the participation of the chlorine atoms from the  $\text{PCl}_3$  group in a reorientational motion between equilibrium position about their symmetry axis. The evidence in favour of autonomous reorientations of the  $\text{PCl}_3$  group (in contrast to reorientations of

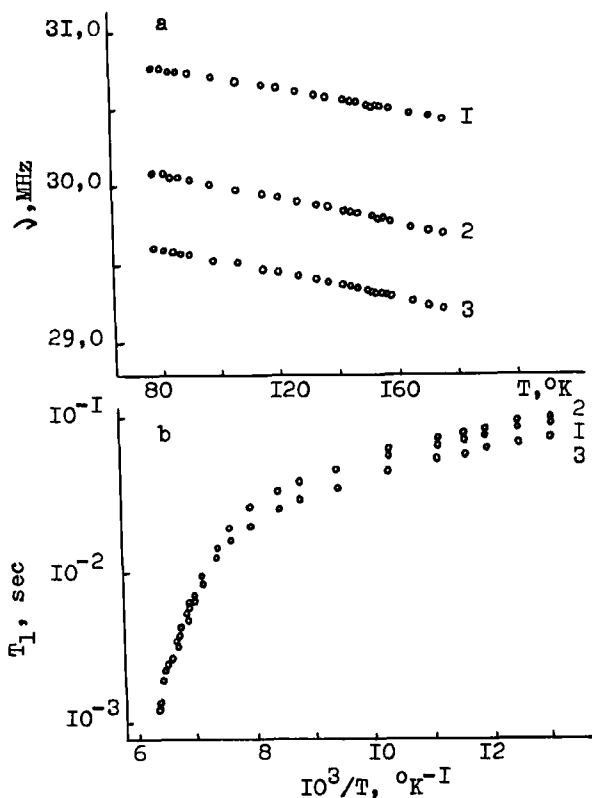


FIG. 1

The temperature dependence of the resonance frequencies (a) and of the quadrupole spin-lattice relaxation time (b) of the  $^{35}\text{Cl}$  nuclei in  $\text{Cl}_3\text{P}=\text{NCOCF}_3$

the entire molecule) was obtained by studying temperature dependences of the  $^{35}\text{Cl}$  NQR parameters for the C-Cl and  $\text{CCl}_3$  groups in the compounds I and II, and those of the  $^{19}\text{F}$  NMR parameters for the  $\text{CF}_3$  group in III.

As seen from the Figure the equalization of the exponentially decreasing time  $T_1$  for all three chlorine nuclei of

the PCl<sub>3</sub> group proceeds without an influence on the splittings in the resonance spectrum. It is connected with the fact that the reorientation rate which causes the signal fading out remains much lower than the NQR frequencies.

The relaxation process is determined by two relaxation mechanisms that combine additively. The former one represents librations and dominates at the low temperatures and the latter one is produced by reorientations which are effective at the high temperatures. Temperature dependence of the relaxation rates may therefore be described by a combined equation<sup>2,3</sup>:

$$(T_1^{-1})_{\text{observ}} = (T_1^{-1})_{\text{libr}} + (T_1^{-1})_{\text{reor}} = aT^n + b \exp\left(-\frac{V_0}{RT}\right)$$

Here  $V_0$  is reorientational potential barrier which may be determined by a mathematical fitting of the experimental data together with  $a, b$ , and  $n$  parameters<sup>4</sup> (Table I, 2).

TABLE I  
The Parameters of Eq. for Cl<sub>3</sub>P=NCOCF<sub>3</sub>

<sup>35</sup> Cl NQR line	:	n	:	-log a	:	log b	:	V <sub>0</sub> , kcal/mol
lower	:	2.24±0.11	:	3.08±0.22	:	11.16±0.40	:	6.07±0.28
middle	:	2.37±0.13	:	3.47±0.26	:	11.39±0.39	:	6.23±0.27
upper	:	2.10±0.04	:	2.91±0.08	:	11.23±0.43	:	6.11±0.30
fitting of all the lines in common <sup>4</sup>	:	-	:	-	:	11.30±0.22	:	6.16±0.15

TABLE 2

The  $^{35}\text{Cl}$  NQR Frequencies and the Reorientation Barriers of the  $\text{PCl}_3$  Group in Trichlorophosphazocompounds

Substance	Tm.p., $^{\circ}\text{K}$	$\nu_{\text{P-Cl}}$ MHz, $77^{\circ}\text{K}$	Tf, $^{\circ}\text{K}$	$V_0$ , kcal/mol
$\text{Cl}_3\text{P=NCCL}(\text{CCl}_3)_2$	326	29.442 29.481 29.764	180	$6.8 \pm 0.2$
$\text{Cl}_3\text{P=NP(O)}(\text{CCl}_3)_2$	395	29.718 30.070 30.320	145	$5.1 \pm 0.1$
$\text{Cl}_3\text{P=NCOCF}_3$	245	29.600 30.085 30.762	175	$6.2 \pm 0.2$

The results of the present paper together with the data of<sup>I</sup> show that the potential barrier for the  $\text{PCl}_3$  group reorientation about the  $\text{P=N}$  bond in several trichlorophosphazocompounds does not exceed  $5 \pm 7$  kcal/mol. Since in a crystal the hindering potential is caused by intra- and intermolecular factors one may conclude that the threefold reorientational barrier about  $\text{P=N}$  bond have an even smaller value(cf.<sup>5</sup>). Thus, electronic distribution along the  $\text{P=N}$  bond does not produce an essential hindrance for the reorientational motion about this bond.

## REFERENCES

1. R.M.Hart, M.A.Whitehead, Molec.Phys.,19, 383 (1970).
2. D.E.Woessner, H.S.Gutowsky, J.Chem.Phys.,39,440 (1963).
3. N.E.Ainbinder, B.F.Amirkhanov, I.V.Ismestiev, A.N.Osipenko G.B.Soifer, Phys.of Solids (USSR), 13, 424 (1971).
4. V.A.Mokeeva, I.V.Ismestiev, I.A.Kjunzel, G.B.Soifer, Phys.of Solids (USSR), 16, 1714 (1974).
5. J.Bragin, S.Chan, E.Mazzola, H.Goldwhite, J.Phys.Chem., 77, 1506 (1973).

Received January 29, 1975

Accepted February 25, 1975