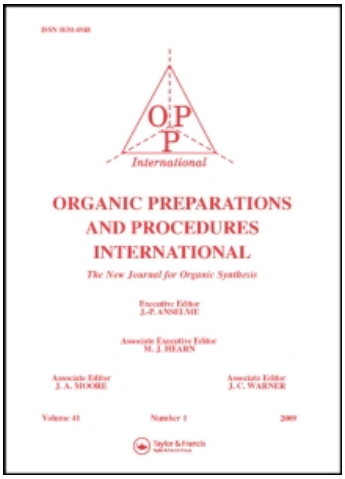


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# RECENT PROGRESS IN THE SYNTHESIS AND REACTIONS OF TETRAZINES. A BRIEF REVIEW

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# RECENT PROGRESS IN THE SYNTHESIS AND REACTIONS OF TETRAZINES. A BRIEF REVIEW

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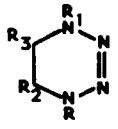
## INTRODUCTION

The tetrazines comprise a family of compounds of outstanding synthetic interest. They present significant challenges to chemists who would study the preparation of their novel and useful analogs, as well as to those intrigued by their unusual structures. This review covers the recent literature of the tetrazines, inclusive of Volume 82 of Chemical Abstracts through the first part of Volume 104, and emphasizes the newer aspects of synthesis. We have attempted to make complete coverage of all the literature references and thus to bring up to date the chemistry of the tetrazines since the time of the last review of encompassing scope.[1a] Excellent critical interpretations of selected fundamental advances in tetrazine chemistry are also available.[1b]

## I. SYNTHESIS

Although preparations have been reported of such 1,2,3,4-tetrazines as



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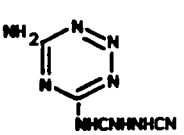

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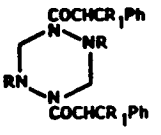
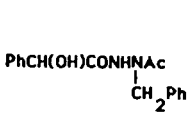


4, R=H
5, R=Ac

1[1c,d-3] and such 1,2,3,5-tetrazines as 2[4-7] much greater effort has been directed at the synthesis of the 1,2,4,5-compounds,[8-38] spurred on in considerable measure by the observation of their herbicidal and physiological activities.[39-41] Acid hydrazides have been especially useful in cyclization approaches.[42-46] Thus Kametani and coworkers discovered that acid-catalyzed cyclization of N'-substituted mandelohydrazides 3 with paraformaldehyde gave hexahydro-1,2,4,5-tetrazines 4, whereas the diacylhydrazine 5 produced 6 when similarly treated. A cyclization-rearrangement

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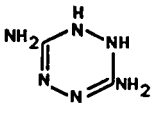

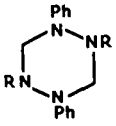

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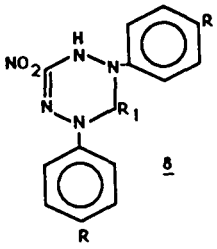

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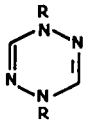
process was proposed.[47-48] Alkaline hydrolysis of thiosemicarbazide is noted as leading to a diaminotetrazine, although its oxidation with lead oxide gave the N-aminotriazole.[49-51]

Lamberton and Nelson noted that a mixture of phenylhydrazine, morpholine and formaldehyde produced the tetrazine 7;[52] although a somewhat more conventional approach to cyclocondensation was taken by Dychenko and Pel'kis, in which isolated phenylhydrazones of nitroformaldehdye were heated with aldehydes in ethanol to allow formation of the compounds 8.[53] The reaction with hydrazine of several benzonitriles in which the aromatic ring was substituted with electron-donating groups, as well as of the parent benzonitrile, led directly to 3,6-bis-substituted-1,2,4,5-tetrazines.[54] The reagent N,N-dimethylamide-phosphoryl chloride reacts with substituted hydrazines in benzene to produce dihydrotetrazines 9, but the method is somewhat limited by low yields and the formation of mixtures.[55]

Cyclization of tetrazolylformazan 10 with formaldehyde gave 11, subsequently oxidized in a procedure which is typical with lead oxide, to the



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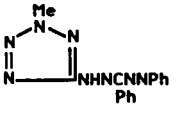

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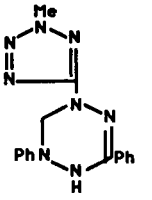

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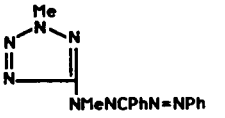

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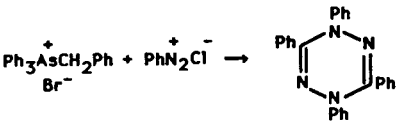
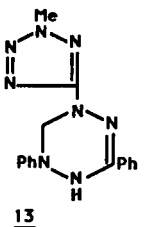
corresponding verdazyl.[56] Phenacyl- and benzyltriphenylarsonium bromides react with aromatic diazonium salts to produce nitrilimines, which



cyclize spontaneously under the reaction conditions, to give the corresponding 1,2-dihydro-1,2,4,5-tetrazines.[57] Several other variations on the basic parameters of the cyclocondensation procedure have been attempted.[58-77]

A number of novel rearrangements produce tetrazines. Jensen and Larson observed the rapid rearrangement at room temperature of thioacethydrazide to 1,4-dihydro-3,6-dimethyl-1,2,4,5-tetrazine via elimination of hydrogen sulfide.[78] Interestingly, dye laser excitation methods[356] have allowed the production of useful quantities of pure sym-tetrazine-$^{13}C$ and sym-tetrazine-$^{15}N$.[79] Thermal rearrangement at 100° converted the tetra-



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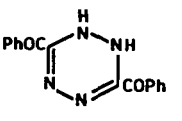

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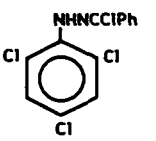

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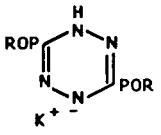
zole 12 to the biheterocyclyl 13.[80] The reaction of α-diazoacetophenone with methanolic sodium methoxide produced the dihydrotetrazine 14, among several products.[81] Tetrazines have also been isolated from the treatment of 2-aminophthalazinium chloride with sodium hydroxide,[82] from the solid

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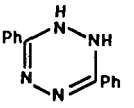


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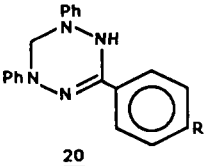


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phase photolysis of 15,[83] from the dimerization of 16 in base to 17[84] and from the hydrolysis rearrangement of 18 to 19.[85] Recent mechanistic studies have now helped to clarify certain reaction pathways generally useful in tetrazine synthesis.[86-88] An elegant total synthesis of streptonigrin employs an important tetrazinecarboxylate intermediate.[89]

## II. OXIDATION AND REDUCTION

Not much work has been done in a systematic way to investigate the oxidation and reduction reactions of the tetrazines.[366] sym-1,2,3,4-Tetrahydrotetrazines were prepared by the hydrogenation of the corresponding dihydro compounds with hydrazine.[90] Substituted dihydrotetrazines can be electrochemically oxidized to give stable radical cations.[91] Although several other oxidative procedures have been recorded,[92-96] it is fair to say that the majority of articles in this vein have had the specific goal of generating verdazyls, as opposed to the conversion of one stable tetrazine compound at a given level of saturation to another stable tetrazine.

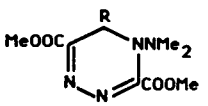
## III. VERDAZYL RADICALS

Clear-cut approaches to the preparation and reactions of verdazyls have emerged, typically involving the oxidation of tetrahydrotetrazines by potassium hexacyanoferrate,[97] lead oxide,[98] or a combination of oxidizing agents.[99,111] In turn, the colorful verdazyls are readily reduced under mild conditions back to their colorless precursors. Compounds 20 were prepared in moderate to good yield by reduction of the corresponding radicals with phenylhydrazine in benzene.[100] Other choices of reducing agent have been hydrazine[101] and hydrazobenzene.[102] The verdazyls undergo bimolecular homolytic substitution with Grignard reagents to produce the N-alkylated tetrahydrotetrazines.[103-105] Strengths for the N-H bond have been determined in certain of these systems[112] and promise to shed further light on the requirements for the homolysis reaction itself. A number of interesting new perfluorophenyl verdazyls have now been prepared.[113] Several other applications of verdazyls to problems in synthesis have been made,[106-109] and a review of recent advances in the chemistry of verdazyl radicals has appeared.[110]



## IV. REARRANGEMENTS

The rearrangement reactions of tetrazines have been particularly useful in heterocyclic synthesis. A recent report includes the details for the thermal conversion of s-tetrazines to 1,2,4-triazoles.[129] A number of workers have made a thorough experimental investigation of the Diels-Alder inverse electron demand cycloaddition reactions of tetrazines.[114-119]

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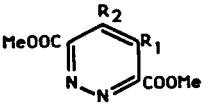


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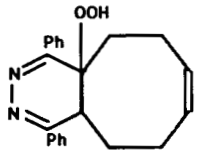
Thus 3,6-dimethoxycarbonyl-1,2,4,5-tetrazine reacted with aldehyde dimethylhydrazones to produce triazines 21, whereas the related ketone hydrazones yielded the pyridazines 22, quite possibly because they reacted in the enehydrazine form;[120] and the cyclization of nontautomerizing anti-α-aminohydrazones into N-aminoimidazolidines has been carried out.[130] Haddadin, Firsan and Nader noted that a variety of enolate ions condensed with 3,6-diphenyl-1,2,4,5-tetrazine to give the 3,6-diphenyl-

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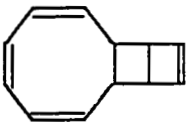

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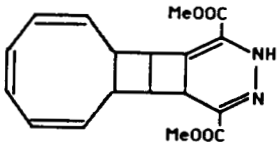


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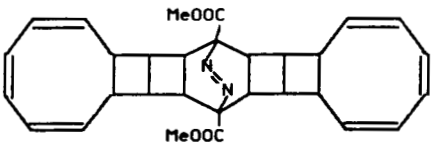
4,5-disubstituted pyridazines.[121] In the reaction of 3,6-diphenyl-sym-tetrazine with cis,cis-1,5-cyclooctadiene, the distribution of products was found to be highly dependent on reaction conditions,[122] with the chief

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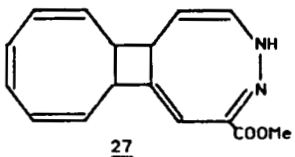


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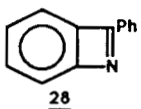
product being the cyclooctapyridazine 23 under mild treatment. Tetrazines react readily with strained small ring compounds to provide a rich complement of novel heterocyclics.[160] The strained double bond of 24, for example, reacted with 3,6-dimethoxycarbonyl-sym-tetrazine to bring forth

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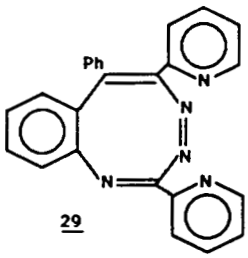


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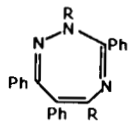


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25-27.[123] Adducts of 28 with dipyridyltetrazine were found to lose carbon monoxide and nitrogen spontaneously to give the benzotriazocine 29.[124] A simple and very effective method for the preparation of 1,2-diazocines has


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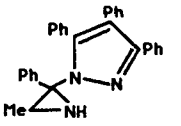


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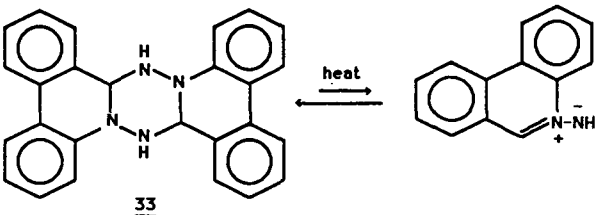
also been advocated.[168] Compound 30 was prepared by cycloaddition of 2-phenyl-1-azirine to 3,6-diphenyl-sym-tetrazine.[125] Similarly, the latter compound also condensed with 31 to give 32.[126] Small ring oxacycles have been examined in this context as well.[127,128]

## V. CYCLOADDITIONS

Fused ring derivative 33 in solution behaved as a 1,3-dipole, giving

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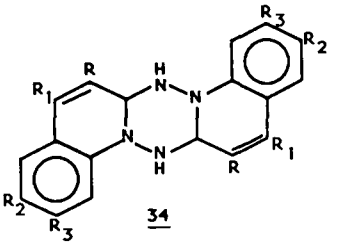
cycloaddition products with α,β-unsaturated carbonyl compounds.[131] In related examples, the irradiation of substituted dimers 34 in methylene chloride containing acetic acid gave the 1H-1,2-benzodiazepines 35 in moderate yields.[132-135] Some work has been done on substituent effects on the reaction rate of 3,6-diaryltetrazines with styrene.[365] Tetrazines have been employed as cycloaddition reactants in probing the behavior of val-

enes[136,145,170] and fulvenes[141,144] and several other highly reactive hydrocarbon derivatives,[137,138,140,149,150,166,168,171] Indoles,[139] oxacycles,[142,158,167] 2-phenylazirines[143] and several azacycles[146,147,157,164] have also been investigated, as well as arsabenzene,[148] thioformamides,[151] isocyanides,[152] hydrazones,[154,162] imines,[155] silylacetylenes,[159] diketene,[161] N,N-dimethylaniline,[163] tricarbonyliron complexes,[165] and arylthioimidates.[169] Some sulfur-containing



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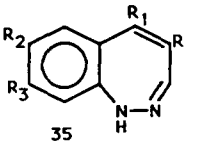

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rings have been examined in this context.[153,156]



## VI. PHYSICAL ORGANIC METHODS AND APPLICATIONS

NMR spectroscopy has found widespread application to the chemistry of the tetrazines.[143,172-175] The earlier extensive studies of the NMR spectra of verdazyl radicals having aliphatic substituents[176] have been followed up in experiments providing new data bearing on the long range ordering of triphenylverdazyl.[177-179] Intra- and intermolecular exchange rates[180] and conformational equilibria[181-182] have been examined for the sym-hexahydrotetrazines as well. The conformations of bi- and tricyclic hexahydrotetrazines have been identified on the basis of their photoelectron spectra,[183] and the analysis of several other problems has been made possible through this method.[184-189] Some mass spectrometric studies have been made on the tetrazines,[362,364] although this specific area has not seen a great deal of activity. The single-electron conversion of the

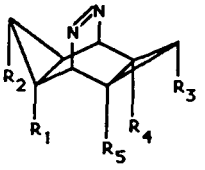
1,3,5-triphenylverdazyl radical into the corresponding cation has been studied by infrared spectroscopy.[190-192] The assignments have been made of visible absorptions of sym-tetrazine,[193,350] and geometrical changes have been correlated with their related absorptions of ultraviolet radiation.[194-202] The radiationless decay of several azabenzenes has been studied by means of opto-acoustic spectroscopy.[203] The fluorescence excitation spectrum of sym-tetrazine at low temperature reveals a smaller geometrical change on electronic excitation than recorded from the analysis of room temperature optical spectra.[204-209,355] Electron-spin resonance methods have allowed determination of nitrogen hyperfine coupling constants,[210] N-H bond strength in leucoverdazyl,[211] conformational preferences,[212] characteristics of liquid crystals,[213-215] and several other properties of the verdazyls.[216-219] The molecular symmetry of the tetrazines is so low that the magnetic circular dichroism spectra contain only the Faraday parameter $\beta$,[220] dependent to a significant extent on the substituents present. The spectroscopy, photophysics and photochemistry of tetrazines in crystals and mixed crystals at low temperatures have been examined.[221-225] Tunable dye laser technology has now made possible the determination of individual molecular isotopes in an unseparated natural mixture.[226-228]

Advances in the area of theory of structure[354] and bonding[359] in the tetrazines include a process for obtaining the diamagnetic anisotropy relative to that of benzene,[229] calculated bond orders[363] and bond lengths[230] and improvements in calculations involving simple ab initio and semiempirical approaches.[231-235]

The photodecomposition of tetrazines has been investigated; [236-240] although much remains to be worked out in terms of the basic photochemical

and photophysical effects,[241-246,353,356,359] it now seems clear that the parent compound decomposes with laser light to yield one nitrogen molecule and two molecules of hydrogen cyanide. In spite of the fact that the Diels-Alder adducts of tetrazines to substituted olefins are modestly stable in a thermal sense,[247-252] some are photolytically labile. Thus the photolysis of 36 led either to homotropilidenes 37 or to the related tetracyclooctanes, depending on the substituents present.[253]

Stable verdazyl radicals have been employed in a variety of roles in several kinds of free radical processes: as hydrogen abstraction agents,[254-265] as quenchers of peroxides,[266-280] as self-regulating antioxidants for organic materials,[281] and as substrates for oxidation-reduction processes.[282-299] Thermochromism of bis-verdazyls has been studied.[300] It is interesting to note that crystal structures have been determined not only for various substituted tetrazines[301-304] but for stable verdazyls as well.[305-307]

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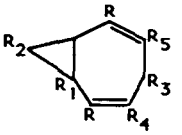


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In agricultural applications, tetrazines have been found useful as bactericidal and fungicidal materials,[308,309] as well as herbicides,[310,311,361] and pesticides.[351] Their toxicology has been discussed.[312-315] In photographic science,[352,357] tetrazines are viable fogging agents for direct positive color diffusion transfer film.[316-318] sym-Tetrazine has been examined as a candidate material for an organic photovoltaic system.[358] Part of the impetus for the investigation of the isotopically selective processes induced by laser excitation was a desire for a better under-

standing of tetrazine photochemistry in the solid state.[319-327] 3,6-bis(4-n-Nonylphenyl)-1,2,4,5-tetrazine has been examined in relation to switching on and switching off time in digital display devices.[328] In the field of synthetic high polymers,[367] the stable triphenylverdazyl has been suggested as an inhibitor of ethyl acrylate with styrene,[329] and in other like processes.[330-345] Trisazo dyes containing a diphenyltetrazinyl moiety were even found efficacious in dyeing cotton, silk and wool bluish black shades[346-349] and tetrazines have been used in water purification,[369] as modifiers of solid propellant burning rates[370] and in pulp processing.[368] With so many useful applications, further rapid growth in tetrazine synthesis can be anticipated.



## REFERENCES

1. (a) "The Chemistry of Heterocyclic Compounds: The Chemistry of 1,2,3-Triazines and 1,2,4-Triazines, Tetrazines and Pentazines", H. Neunhoeffer and P. F. Wiley, Editors, New York, Wiley, 1978, Vol. 33. (b) "Comprehensive Heterocyclic Chemistry", A. R. Katritzky and C. W. Rees, Editors, Oxford, Pergamon Press, 1984. (c) D. Seebach, R. Dach, D. Enders and B. Renger, German Patent 2,327,545; Chem. Abstr., 83, 10166 (1975). (d) D. Seebach, R. Dach, D. Enders, B. Renger, M. Jansen and G. Brachtel, Helv. Chim. Acta, 61, 1622 (1978).

2. G. Sayed, M. Elhalim, M. El-Kady and L. Elwahab, Indian J. Chem., Sect. B, 21B, 589 (1982).

3. S. Sommer and U. Schubert, Angew. Chemie, 91, 757 (1979).

4. K. Kubo, T. Nonaka and K. Odo, Bull. Chem. Soc. Jpn., 49, 1339 (1976).

5. A. Baydar, G. Boyd, P. Lindley and A. Walton, J. Chem. Soc., Perkin Trans. 1, 415 (1985).

6. M. Stevens, J. Hickman, R. Stone, N. Gibson, G. Baig, E. Lunt, C. Newton, J. Med. Chem., 27, 196 (1984).

7. C. C. Cheng, European Pat. Appl. 127028; Chem. Abstr., 102, 132084 (1985).

8. L. Farkas, J. Keuler and H. Wamhoff, Chem. Ber., 113, 2566 (1980).

9. R. Bansal and G. Bhagchandani, Indian J. Chem., Sect. B, 20B, 503 (1981).

10. G. Gupta and H. Pujari, ibid., 20B, 296 (1981).

11. R. Bansal and G. Bhagchandani, ibid., 18B, 362 (1979).

12. J. Johnson, B. Whitney and L. Werbel, J. Heterocycl. Chem., 17, 501 (1980).

13. L. Werbel, D. McNamara, N. Colbry, J. Johnson, M. Degnan and B. Whitney, ibid., 16, 881 (1979).

14. K. Kigasawa, M. Hiiragi, N. Wagatsuma, T. Kohagizawa and H. Inoue, Japanese Patent 79163579; Chem. Abstr., 93, 95302 (1981).

15. T. Oda, T. Maeshima and S. Sugiyama, Nippon Kagaku Kaishi, 915 (1979); Chem. Abstr., 92, 21929 (1980).

16. Anon., Res. Discl., 189, 3 (1980).

17. A. Eremeev, D. Tikhomirova and A. Zidermane, USSR Patent SU 686336; Chem. Abstr., 94, 103442 (1981).

18. I. Postovskii, E. Kovalev and G. Rustinov, USSR Patent SU 2495805; Chem. Abstr., 92, 6564 (1980).

19. N. Bach and E. Kornfeld, U. S. Patent 4235776; Chem. Abstr., 94, 121320 (1981).

20. G. Bemis, R. Whittle, S. Mayo and R. Olofson, Acta Crystallogr., Sect. C, C40, 2076 (1984).

21. H. Inoue, T. Origuchi and K. Umano, Bull. Chem. Soc. Jpn., 57, 806 (1984).

22. N. Bach and E. Kornfeld, Canadian Patent 1117955; Chem. Abstr., 97, 23622 (1982).

23. F. Neugebauer, H. Fischer, R. Siegel and C. Krieger, Chem. Ber., 116, 3461 (1983).

24. F. Neugebauer, C. Krieger, H. Fischer and R. Siegel, ibid., 116, 2261 (1983).

25. T. Kaempchen, W. Massa, W. Overheu, R. Schmidt and G. Seitz, ibid., 115, 683 (1982).

26. K. K. Jain and H. K. Pujari, Indian J. Chem., Sect. B, 21B, 315 (1982).

27. G. Baig, M. Stevens, E. Lunt, C. Newton, B. Pedgrift, C. Smith, R. Walsh and P. Warren, German Patent Application DE 3329505; Chem. Abstr., 101, 23509 (1984).

28. V. Pandey, H. Lohani and A. Agarwal, Indian J. Pharm. Sci., 44, 155 (1982).

29. H. Hassaneen, A. Fahmi, A. Abdelgawad, H. Abdelhamid, A. Yassin and A. Shawali, J. Heterocycl. Chem., 21, 797 (1984).

30. M. Stevens, J. Hickman, R. Stone, N. Gibson, G. Baig, E. Lunt and C. Newton, J. Med. Chem., 27, 196 (1984).

31. L. Rodina, O. Verzhba and I. Korobitsyna, Khim. Geterotsikl. Soedin, 838 (1983).

32. F. Neugebauer and H. Fischer, Ann., 387 (1982).

33. R. Tewari, A. Awasthi and P. Parihar, Synthesis, 334 (1983).

34. G. Shustov, N. Tavakalyan and R. Kostyanovskii, Tetrahedron, 41, 575 (1985).

35. V. Bodnar, M. Lozinskii and P. Pelkis, Ukr. Khim. Zh., 48, 1308 (1982); Chem. Abstr., 98, 126041 (1983).

36. W. Schliemann, Wiss. Z.-Martin-Luther-Univ. Halle-Wittenberg, Math.-Naturwiss. Reihe, 30, 65 (1981); Chem. Abstr., 96, 142811 (1982).

37. G. Gadzhiev, Zh. Org. Khim., 20, 510 (1984).

38. B. Shainyan, A. Mirskova, A. Istomin, V. Vitkovskii and I. Kalikhman, ibid., 17, 2463 (1981).

39. O. Fostad, S. Aamdal, A. Pihl and M. Boyd, Cancer Res., 45, 1778 (1985).

40. E. Lunt, M. Stevans, R. Stone and K. Wooldridge, German Patent Application DE 3231255; Chem. Abstr., 98, 198285 (1983).

41. R. Lowe, C. Schwalbe and M. Stevens, J. Chem. Soc., Perkin Trans. 2, 357 (1985); N. Bach, E. Kornfeld, N. Jones, M. Chaney, D. Dorman, J. Paschal, J. Clemens and E. Smalstig, J. Med. Chem., 23, 481 (1980); C. Horgan and M. Tisdale, Biochem. Pharmacol., 33, 2185 (1984); C. Goddard, J. Slack and M. Stevens, Br. J. Cancer, 52, 37 (1985); M. Stevens, J. Hickman, R. Stone, N. Gibson, G. Baig, E. Lunt and C. Newton, J. Med. Chem., 27, 196 (1984); J. Slack and C. Goddard, J. Chromatogr., 337, 178 (1985).

42. K. Pilgram and R. Skiles, U. S. Patent 3860588; Chem. Abstr., 82, 112113 (1975).

43. K. Pilgram and R. Skiles, U. S. Patent 3860589; Chem. Abstr., 82, 112112 (1975).

44. L. Yagupolskii, G. Matyushecheva, V. Mikhailov and L. Bulygina, USSR Patent SU 498300; Chem. Abstr., 84, 135727 (1976).

45. H. Neunhoeffer and H. Degen, Chem. Ber., 108, 3509 (1975).

46. G. Zinner and T. Krause, Arch. Pharm. (Weinheim), 310, 704 (1977).

47. T. Kametani, K. Kigasawa, M. Hiragi, N. Wagatsuma, T. Kohagizawa and H. Inoue, Yakugaku Zasshi, 99, 135 (1979).

48. T. Kametani, K. Kigasawa, M. Hiragi, N. Wagatsuma, T. Kohagizawa and H. Inoue, Heterocycles, 9, 1031 (1978).

49. A. Katunina, E. Kovalev and G. Kitaev, Khim. Geterotsikl. Soedin., 847 (1975).

50. G. Zinner, T. Krause and K. Doerschner, Arch. Pharm. (Weinheim), 310, 642 (1977).

51. R. Esmail and F. Kurzer, J. Chem. Soc., Perkin Trans. 1, 1787 (1975).

52. J. Lamberton and E. Nelson, Australian J. Chem., 29, 1853 (1976).

53. A. Dychenko and P. Pel'kis, Ukr. Khim. Zh., 43, 1192 (1977); Chem. Abstr., 88, 62367 (1978).

54. W. Guither, M. Coburn and R. Castle, Heterocycles, 12, 745 (1979).

55. V. Sergutina, K. Zelenin and V. Khrustalev, Zh. Org. Khim., 14, 622 (1978). For further examples of hydrazine substitution, see E. Kovalev, Y. Postovskii and G. Rustinov, Dokl. Akad. Nauk SSR, 241, 366 (1978). For an inorganic example, see: M. Herberhold and M. Suess-Fink, Z. Naturforsch., B: Anorg. Chem., Org. Chem., 31B, 1489 (1976).

56. V. Shchipanov, E. Sidorov, L. Podenko and G. Kadochnikova, Khim. Geterotsikl. Soedin., 991 (1978).

57. R. Bansal and S. Sharma, J. Organomet. Chem., 155, 293 (1978).

58. R. Bansal and S. Sharma, J. prakt. Chem., 321, 519 (1979).

59. H. Degen, S. Haller, K. Heeg and H. Neunhoeffer, Chem. Ber., 112, 1981 (1979). Compare: M. Takahashi, H. Tan, K. Fukushima and H. Yamazaki, Bull. Chem. Soc. Jpn., 50, 953 (1977); V. Ivanova, B. Buzykin and Y. Kitaev, Izv. Akad. Nauk SSR, Ser. Khim., 393 (1977); V. Ivanova, B. Buzykin and Y. Kitaev, Nov. Polyarogr., Tezisy Dokl. Vses. Soveshch. Polyarogr., 83 (1975) [Chem. Abstr., 86, 80816 (1977)]. For an important synthesis of 12-azasteroids, note: H. Neunhoeffer and H. Metz, Ann., 1476 (1983).

60. V. Cohen, J. Heterocycl. Chem., 15, 1113 (1978).

61. A. Eremeev, D. Tikhomirov, V. Tyusheva and E. Liepins, Khim. Geterotsikl. Soedin., 753 (1978).

62. V. Dubina, I. Dembinskii and V. Pendan, Zh. Org. Khim., 13, 2381 (1977).

63. V. Shchipanov and A. Azbolotskaya, Tezisy-Dokl.-Nauchno-Tekh. Konf. "Khim. Primen. Formazanov," 11 (1974); Chem. Abstr., 87, 53231 (1977).

64. G. Zinner and T. Krause, Chem. Ztg., 101, 302 (1977).

65. A. Mangia, F. Bortesi and U. Amendola, J. Heterocycl. Chem., 14, 587 (1977).

66. R. Grashey. M. Weidner, C. Knorn and H. Bauer, Chem. Ztg., 100, 496 (1976).

67. A. Lazaris, S. Shmuilovich and A. Egorochkin, Khim. Geterotsikl. Soedin., 713 (1976).

68. V. Fomenko and O. Shvaika, ibid., 629 (1976).

69. S. Goya, A. Takadate and T. Tanaka, Yakugaku Zasshi, 96, 700 (1976).

70. F. Neugebauer, H. Fischer and R. Bernhardt, Chem. Ber., 109, 2389 (1976).

71. B. Buzykin, L. Sysoeva and Y. Kitzev, Zh. Org. Khim., 12, 1676 (1976).

72. E. Fluck and H. Schultheiss, Ann., 1851 (1974).

73. S. Lang, Jr., B. Johnson and E. Cohen, J. Heterocycl. Chem., 12, 1143 (1975).

74. A. Shawali and A. Abdelhamid, Bull. Chem. Soc. Jpn., 49, 321 (1976).

75. G. McConnachie and F. Neugebauer, Tetrahedron, 31, 555 (1975).

76. S. Lang, Jr., E. Cohen and A. Sloboda, U. S. Patent 3863010; Chem. Abstr. 83, 43387 (1975).

77. R. Dickinson and N. Jacobsen, J. Chem. Soc., Perkin Trans. 1, 975 (1975). See also H. Boehme, J. Denis and T. Kaempchen, Chem. Ber., 115, 2947 (1982).

78. K. Jensen and E. Larsen, Acta Chem. Scand., Ser. A, A33, 137 (1979).

79. U. Boesl, H. Neusser and E. Schlag, Chem. Phys. Lett., 61, 62 (1979). For a description of incorporation of $^{15}N$-hydrazine into a preformed tetrazine ring, see A. Counotte-Potman and H. van der Plas, J. Heterocycl. Chem., 15, 445 (1978).

80. V. Shchipanov, S. Nagovskaya and L. Podenko, Khim. Geterotsikl. Soedin., 226 (1977).

81. P. Yates and R. Mayfield, Can. J. Chem., 55, 145 (1977). Compare G.

Ege and K. Gilbert, Tetrahedron Lett., 4253 (1979).

82. K. Lempert and K. Zauer, Acta Chim. Acad. Sci. Hung., 88, 81 (1976).

83. A. Friedman, K. Koshy and A. van der Slik, Environ. Qual. Saf., 3, Supplement 298 (1975); Chem. Abstr., 85, 138598 (1976).

84. W. Disteldorf and M. Manfred, Ann., 225 (1976). For the resolution of an interesting structural problem, see M. Bryce, Z. Dauter, T. Kaempchen, C. Reynolds and G. Seitz, Acta Crystallogr., Sect. C, Cryst. Struct. Commun., C40, 1934 (1984).

85. G. Merrill and H. Schechter, Tetrahedron Lett., 4527 (1975).

86. A. Almerico and A. Boulton, Chem. Commun., 204 (1985).

87. D. Hunter and D. Neilson, J. Chem. Soc., Perkin Trans. 1, 1081 (1985). Also note D. Hunter and D. Neilson, ibid., 1371 (1981).

88. A. Counotte-Potman, INIS Atomindex, 13, Abstr. 64705 (1982);Chem. Abstr., 97, 5492 (1982). See also: A. Counotte-Potman, H. van der Plas, B. van Veldhuizen and C. Landheer, J. Org. Chem., 46, 5102 (1981). The presumed thermal chemistry of 1,2,3,4-tetrazine has now been inferred from the base-catalyzed decomposition of acenaphthenequinone bis(sulfonylhydrazones): S. Chang, Synth. Commun., 12, 673 (1982). For an interesting account of the thermal behavior of dimethyltetrazine on platinum, see D. Dahlgren and J. Hemminger, Surf. Sci., 120, 456 (1982).

89. D. Boger and J. Panek, J. Org. Chem., 48, 621 (1983); D. Boger, J. Panek and S. Duff, J. Am. Chem. Soc., 107, 5745 (1985); D. Boger, R. Coleman, J. Panek and D. Yohannes, J. Org. Chem., 49, 4405 (1984).

90. E. Zaika and O. Polumbrik, USSR Patent SU 496280; Chem. Abstr., 84, 121910 (1976).

91. V. Ivanova, B. Buzykin, L. Sysoveva and Y. Kitzev, Izv. Akad. Nauk SSR, Ser. Khim., 2499 (1978). Compare A. Nesterenko, O. Polumbrik and L. Markovskii, Zh. Org. Khim., 19, 1961 (1983).

92. R. Grashey. M. Weidner, C. Knorn and H. Bauer, Chem. Ztg., 100, 496 (1976).

93. S. Auricchio, G. Vidari and P. Vita-Finzi, Gazz. Chim. Ital., 106, 1 (1976).

94. K. Pilgram and R. Skiles, J. Org. Chem., 41, 3392 (1976).

95. D. Hunter, D. Neilson and T. Weakley, J. Chem. Soc., Perkin Trans. 1, 1165 (1982).

96. A. Counotte-Potman and H. van der Plas, J. Heterocycl. Chem., 18, 123 (1981).

97. O. Polumbrik, I. Ryabokon and L. Markovskii, Khim. Geterotsikl.

Soedin., 266 (1978).
98. L. Surovtsev, V. Shchipanov, V. Kiselev and N. Doronina, USSR Patent SU 591469; Chem. Abstr., 88, 170202 (1978).

99. V. Shchipanov, Khim. Geterotsikl. Soedin., 1428 (1974).

100. P. Tarasenko and E. Ponomareva, Visn. Kiiv. Politekh Insti., Ser. Khim. Mashinobudav. Tekhnol., 14, 25 (1977).

101. O. Polumbrik and E. Zaika, Dopov. Akad. Nauk Ukr. RSR, Ser. B, 732 (1975).

102. E. Ponomareva, T. Pervishko, N. Kulik and V. Premyslov, Vestn. Kiev. Politekh. Inst., Khim. Mashinostr. Tekhnol., 15, 24 (1978).

103. Y. Miura, Y. Morimoto and M. Kiuoshita, Bull. Chem. Soc. Jpn., 49, 1715 (1976).

104. Y. Miura, Y. Morimoto and M. Kiuoshita, ibid., 49, 252 (1976).

105. Y. Miura, Y. Morimoto and M. Kiushita, Chem. Lett., 19 (1975); cf. E. Tomilenko, V. Staninets and G. Udovin, Khim. Geterotsikl. Soedin., 417 (1977).

106. E. Ponomareva, V. Premyslov and G. Dvorko, Dopov. Akad. Nauk Ukr. RSR, Ser. B: Geol., Khim., Biol. Nauki, 1099 (1977).

107. V. Shchipanov, Khim. Geterotsikl. Soedin., 557 (1977).

108. O. Polumbrik, N. Vasilkevich and V. Kalinin, Ukr. Khim. Zh., 42, 724 (1976).

109. E. Ponomareva, P. Tarasenko and G. Dvorko, Angew. Chem., 87, 453 (1975); cf. V. Shchipanov and G. Kadochnikova, Khim. Geterotsikl. Soedin., 1137 (1978).

110. O. Polumbrik, Usp. Khim., 47, 1444 (1978).

111. F. Neugebauer and H. Fischer, Angew. Chem., 92, 766 (1980).

112. O. Polumbrik, A. Misyura and L. Markovskii, Dopov. Akad. Nauk Ukr. RSR, Ser. B, Geol., Khim., Biol. Nauki, 54 (1985); Chem. Abstr., 102, 203378 (1985).

113. O. Polumbrik, I. Ryabokon and L. Markovskii, Khim. Geterotsikl. Soedin., 1130 (1980); cf. L. Markovskii, L. Kachkovskaya, V. Bobkov and P. Kornuta, Zh. Org. Khim., 20, 1346 (1984).

114. G. Seitz and W. Overheu, Chem. Ztg., 103, 230 (1979).

115. G. Seitz, T. Kaempchen and W. Overheu, Arch. Pharm. (Weinheim), 311, 786 (1978).

116. G. Seitz and W. Overheu, ibid., 310, 936 (1977).

117. G. Seitz and T. Kaempchen, ibid., 309, 679 (1976).

118. G. Seitz and T. Kaempchen, Chem. Ztg., 292 (1975).

119. G. Seitz and T. Kaempchen, Arch. Pharm. (Weinheim), 308, 237 (1975).

120. G. Seitz and W. Overheu, ibid., 312, 452 (1979). See also G. Seitz and W. Overheu, ibid., 314, 376 (1981). For recent examples, consult H. Figueys and A. Mathy, Tetrahedron Lett., 22, 1393 (1981).

121. M. Haddadin, S. Firsan and B. Nader, J. Org. Chem., 44, 629 (1979). Compare G. Rusinov, I. Postovskii and E. Kovalev, Dokl. Akad. Nauk SSSR, 253, 1392 (1980); E. Kovalev, I. Postovskii, G. Rusinov and I Shegal, Khim. Geterotsikl. Soedin., 1462 (1981). For the preparation of heteroannulated pyridazines, see G. Seitz and L. George, Chem. Ztg., 108, 331 (1984).

122. S. Satish, A. Mitra and M. George, Tetrahedron, 35, 277 (1979).

123. R. Neuberg, G. Schroeder and J. Oth, Ann., 1368 (1978).

124. B. Adger, C. Rees and R. Storr, J. Chem. Soc., Perkin Trans. 1, 45 (1975).

125. V. Nair, J. Heterocycl. Chem., 12, 183 (1975); cf. C. Jennison, Diss. Abstr. Int. B, 37, 5085 (1977).

126. R. Moerck and M. Battiste, Chem. Commun., 782 (1974).

127. H. Scharf and J. Mattay, Tetrahedron Lett., 401 (1977).

128. H. Scharf and J. Mattay, ibid., 3509 (1976).

129. D. Hunter and D. Neilson, J. Chem. Soc., Perkin Trans. 1, 2779 (1984). See also D. Hunter and D. Neilson, ibid., 1601 (1983).

130. H. Gnichtel, L. Belkien, W. Totz and L. Wawretschek, Ann., 1016 (1980); in this same vein, see B. Buzykin, N. Gazetdinova, S. Yakupova, A. Stolyarov, Z. Titova and Y. Kitaev, Izv. Akad. Nauk SSSR, Ser. Khim., 1588 (1983).

131. R. Huisgen, R. Grashey and R. Krischke, Ann., 506 (1977). See also R. Grashey and E. Jaenchen, Chem. Ztg., 104, 240 (1980).

132. T. Tsuchiya, J. Kurita and V. Snieckus, J. Org. Chem., 42, 1856 (1977).

133. T. Tsuchiya and J. Kurita, Japanese Patent 76 75089; Chem. Abstr., 86, 121380 (1977).

134. J. Kurita, T. Tsuchita and H. Igeta, Hukusokan Kagaku Toronkai Koen Yoshishu, 209 (1975); Chem. Abstr., 84, 164740 (1976).

135. T. Tsuchiya, J. Kurita, H. Igeta and V. Snieckus, Chem. Commun., 640 (1974).

136. M. Christi, H. Lueddeke, A. Nagyrevi-Neppel and G. Freitag, Chem. Ber., 110, 3745 (1977).

137. P. A. Harrison, R. Russell, R. Warrener and M. Paddon-Row, Tetrahedron Lett., 3291 (1977).

138. A. Anastassiou and E. Reichmanis, Chem. Commun., 313 (1976).

139. M. Takahashi, H. Ishida and M. Kohmoto, Bull. Chem. Soc. Jpn., 49, 1725 (1976).

140. A. Anastassiou and G. Girgenti, Angew. Chem., 87, 842 (1975).

141. T. Sasaki, K. Kanematsu and T. Kataoka, J. Org. Chem., 40, 1201 (1975).

142. T. Sasaki, K. Kanematsu, K. Iizuka and I. Ando, ibid., 41, 1425 (1976).

143. T. Tsujimoto, C. Kobayashi, T. Nomura, M. Iifuru and Y. Sasaki, Chem. Pharm. Bull., 27, 2105 (1979). M. Takahaski, N. Suzuki and Y. Igari, Bull. Chem. Soc. Jpn., 48, 2605 (1975); compare M. Lempert-Sreter, K. Lempert, J. Tamas and K. Vekey, Acta Chim. Acad. Hung., 103, 259 (1980).

144. R. Warrener, M. Paddon-Row, R. Russell and P. Watson, Australian J. Chem., 34, 397 (1981).

145. D. Paske, R. Ringshandl, I. Sellner, H. Sichert and J. Sauer, Angew. Chem., 92, 464 (1980).

146. N. Bach and E. Kornfeld, Belgian Patent BE 877329; Chem. Abstr., 93, 26277 (1980).

147. G. Beynon, H. Figeys, D. Lloyd and R. Mackie, Bull. Soc. Chim. Belg., 88, 905 (1979).

148. A. Ashe, III, W. Chan, T. Smith and K. Taba, J. Org. Chem., 46, 881 (1981).

149. A. Schultz, M. Shen and R. Ravichandran, Tetrahedron Lett., 22, 1767 (1981).

150. R. Warrener, D. Evans, M. Paddon-Row and R. Russell, Australian J. Chem., 35, 757 (1982).

151. G. Seitz, R. Mohr, W. Overheu, R. Allmann and M. Nagel, Angew. Chem., 96, 885 (1984).

152. P. Imming, R. Mohr, E. Mueller, W. Overheu and G. Seitz, ibid., 94, 291 (1982).

153. G. Seitz, R. Dhar, R. Mohr and W. Overheu, Arch. Pharm. (Weinheim), 317, 237 (1984).

154. G. Seitz, R. Dhar and D. Sabine, ibid., 316, 472 (1983).

155. U. Berger, G. Dannhardt and R. Obergrusberger, ibid., 315, 428 (1982); see also G. Gribble, C. LeHoullier, M. Sibl and R. Allen, J. Org. Chem., 50, 1611 (1985).

156. G. Seitz, T. Kaempchen, W. Overheu and U. Martin, Arch. Pharm. (Weinheim), 314, 892 (1981).

157. R. Askani and W. Schneider, Chem. Ber., 116, 2366 (1983).

158. R. Dhar, W. Huehnermann, T. Kaempchen, W. Overheu and G. Seitz, ibid., 116, 97 (1983).

159. L. Birkofer, E. Haensel and A. Steigel, ibid., 115, 2574 (1982); L. Birkofer and E. Haensel, ibid., 114, 3154 (1981).

160. F. Huber, J. Sauer, W. McDonald and H. Noeth, ibid., 115, 444 (1982).

161. G. Seitz, R. Dhar and R. Mohr, Chem. Ztg., 107, 172 (1983). In the same vein, see also H. P. Figueys, A. Mathy and A. Dralants, Synth. Commun., 11, 655 (1981); K. Mueller and J. Sauer, Tetrahedron Lett., 25, 2541 (1984); and H. Schuster and J. Sauer, ibid., 24, 4087 (1983).

162. G. Seitz, R. Dhar and W. Huehnermann, Chem. Ztg., 106, 100 (1982).

163. G. Seitz, T. Kaempchen, W. Overheu and U. Martin, ibid., 105, 342 (1981).

164. A. Marcelis and H. van der Plas, Heterocycles, 23, 683 (1985); compare J. Baker, W. Hedges, J. Timberlake and L. Trefonas, J. Heterocycl. Chem., 20, 855 (1983).

165. T. Ban, K. Nagai, Y. Miyamoto, K. Harano, M. Yasuda and K. Kanematsu, J. Org. Chem., 47, 110 (1982).

166. J. Pawliszyn, M. Szczesniak and S. Scheiner, J. Phys. Chem., 88, 1726 (1984).

167. H. Gnichtel and C. Gumprecht, Ann., 628 (1985).

168. M. Haddadin, B. Agha and S. Salker, Tetrahedron Lett., 25, 2577 (1984).

169. D. Boger and J. Panek, ibid., 24, 4511 (1983).

170. H. Schuster, H. Sichert and J. Sauer, ibid., 24, 1485 (1983).

171. J. Balcar, G. Chrisman, F. Huber and J. Sauer, ibid., 24, 1481 (1983).

172. K. Ebraheem, G. Webb and M. Witanowski, Org. Magn. Reson., 11, 27 (1978).

173. G. Pousard and M. Rajzmann, ibid., 8, 271 (1976).

174. L. Stefaniak, Spectrochim. Acta, Part A, 32A, 345 (1976).

175. A. Counotte-Potman, H. van der Plas, B. van Veldhuisen, J. Org. Chem., 46, 3805 (1981); A. Counotte-Potman, H. van der Plas and B. van Veldhuisen, ibid., 46, 2138 (1981); C. Stam, A. Counotte-Potman and H. van der Plas, ibid., 47, 2856 (1982); M. Witanowski, L. Stefaniak, H. Januszewski and G. Webb, J. Magn. Reson., 16, 69 (1974).

176. F. Neugebauer and H. Brunner, Tetrahedron, 30, 2841 (1974).

177. J. Yamauchi, Y. Deguchi and N. Azuma, Chem. Lett., 553 (1979).

178. A. Karmilov, N. Sysoeva and G. Salitra, Zh. Fiz. Khim., 52, 2443 (1978).

179. W. Mueller-Warmuth, R. Vilhjalmsson, P. Gerlof, J. Smidt and J. Trommel, Mol. Phys., 31, 1055 (1976).

180. S. Alber, G. Lagodzinskaya, G. Manelis and E. Feldman, Izv. Akad. Nauk SSR, Ser. Khim., 1314 (1975).

181. A. Katritzky, V. Baker, F. Brito-Palma, J. Sullivan and R. Finzel, J. Chem. Soc., Perkin Trans. 2, 1133 (1979); cf. V. Baker, A. Katritzky, J. Majoral, A. Martin and J. Sullivan, J. Am. Chem. Soc., 98, 5748 (1976).

182. A. Katritzky, I. Ferguson and R. Patel, J. Chem. Soc., Perkin Trans. 2, 981 (1979).

183. P. Rademacher, H. Breier and R. Poppele, Chem. Ber., 112, 853 (1979).

184. W. von Niessen and G. Dierckson, Chem. Phys., 41, 113 (1979).

185. J. Puttemans, Ing. Chem. (Brussels), 60, 3 (1978).

186. P. Rademacher and H. Koopman, Chem. Ber., 109, 1557 (1975).

187. P. Bischof, R. Gleiter, R. Dach, D. Enders and D. Seebach, Tetrahedron, 31, 1415 (1975); compare E. Thulstrup, J. Spanget-Larsen and R. Gleiter, Mol. Phys., 37, 1381 (1979).

188. S. Nelson and J. Buschek, J. Am. Chem. Soc., 96, 6982 (1974).

189. I. Stankevich and O. Tomlin, Zh. Strukt. Khim., 1004 (1974).

190. L. Kotorlenko, V. Aleksandrova and L. Degtyarev, Deposited Doc., VINITI, 2208 (1977); Chem. Abstr., 90, 71456 (1979); for a related infrared study allowing for the determination of intermolecular potentials, see Z. Gamba and H. Bonadeo, Chem. Phys. Lett., 69, 525 (1980).

191. L. Kotorlenko, V. Aleksandrova and L. Degtyarev, Zh. Prikl. Spektrosk., 27, 356 (1977).

192. L. Kotorlenko, V. Aleksandrova, G. Novozhilova and E. Rozantsev., Teor. Eksp. Khim., 14, 762 (1978); R. Mathis, F. Mathis, M. Chihaoui and B. Baccar, Spectrochim. Acta, Part A, 38A, 133 (1982).

193. K. Innes, L. Franks, A. Merer, G. Vemulapalli, T. Cassen and J. Lowry, J. Mol. Spectrosc., 66, 465 (1977); for a discussion of the resonant CARS spectroscopy of s-tetrazine vapor, see T. Aartsma, W. Hesselwink and D. Wiersma, Chem. Phys. Lett., 71, 424 (1980).

194. F. Newberger and H. Fischer, Collog. Int. C.N.R.S., 278, 79 (1978).

195. V. Job and K. Innes, J. Mol. Spectrosc., 71, 299 (1978); K. Thakur, V. Job and V. Kartha, ibid., 112, 340 (1985); K. Thakur, V. Job and V. Kartha, ibid., 107, 373 (1984).

196. D. Coulter, H. Reisler, G. Wittig and Dows, Spriner Ser. Chem. Phys., 3, 82 (1978).

197. J. LeClerq, P. Yvan and J. M. LeClerq, Chem. Phys., 22, 233 (1977).

198. H. Koopman and P. Rademacher, Spectrochim. Acta, Part A, 32A, 157 (1976).

199. V. Bolotin, V. Zurba, N. Kruglyak, L. Balevisius and A. Bolotin, Liet. Fix. Rinkinys, 14, 561 (1974); Chem. Abstr., 83, 17835 (1975).

200. T. Ha, Mol. Phys., 29, 1829 (1975).

201. J. Meyling, R. van der Werf and D. Wiersma, Chem. Phys. Lett.,28, 364 (1974).

202. A. Bogatyreva, O. Polumbrik and A. Buchachenko, Izv. Akad. Nauk SSR, Ser. Khim., 2204 (1974).

203. K. Kaya, C. Chatelain, M. Robin and N. Kuebler, J. Am. Chem. Soc., 97, 2153 (1975); cf. A. Knight and C. Parmenter, Chem. Phys., 15, 85 (1976) and O. Polumbrik, A. Zhurba and B. Yarmolyuk, Zh. Anal. Khim., 31, 2436 (1976).

204. R. Smalley, L. Wharton, D. Levy and D. Chandler, J. Mol. Spectrosc., 66, 375 (1977). See also D. Brumbaugh and K. Innes, Chem. Phys., 59, 413 (1981).

205. R. Smalley, L. Wharton, D. Levy and D. Chandler, J. Chem. Phys., 68, 2487 (1978); D. Hoskin, Diss. Abstr. Int. B, 42, 213 (1981).

206. R. Smalley, D. Levy and L. Wharton, Laser Focus, 11, 40 (1975).

207. R. Hochstrasser, D. King and A. Nelson, Chem. Phys. Lett., 42, 8 (1976).

208. J. Kalinowski, J. Godlewski and R. Chance, J. Chem. Phys., 64, 2389 (1976).

209. R. Hochstrasser and D. King, Chem. Phys., 5, 439 (1974). For a complementary study on s-tetrazine vibrational relaxation in solution, see P. Barbara, L. Brus and P. Rentzepis, Chem. Phys. Lett., 69, 447 (1980).

210. K. Mukai, H. Shikata, N. Azuma and K. Kuwata, J. Magn. Reson., 35, 133 (1979).

211. O. Polumbrik and I. Ryabokon, Zh. Org. Khim., 14, 1332 (1978); O. Polumbrik, I. Ryabokon, E. Skorobagat'ko, A. Nesterenko and L. Markovskii, ibid., 18, 1065 (1982).

212. L. Degtyarev and Y. Gorlov, Zh. Strukt. Khim., 16, 769 (1975); K. Pilgram, L. Gale and R. Skiles, J. Heterocycl. Chem., 22, 643 (1985).

213. Chisso Corporation, Japanese Patent JP 8118675; Chem. Abstr., 95, 124104 (1981); G. Kothe and E. Ohmes, J. Mol. Struct., 46, 481 (1978).

214. G. Kothe, Mol. Phys., 33, 147 (1977); D. Demus, G. Pelzl, H. Zaschke and R. Wolff, German Patent DD 137202; Chem. Abstr., 92, 102334 (1980); H. Schubert, D. Demus, H. Zaschke, F. Kuschel, G. Pelzl, H. Nothnik and W. Schliemann, German Patent DE 2841245; Chem. Abstr., 92, 13707 (1980).

215. G. Kothe, A. Naujok and E. Ohmes, Mol. Phys., 32, 1215 (1976); D. Demus, H. Zaschke, G. Pelzl, H. Enzenberg and A. Isenberg, British Patent Appl. GB 2138838; Chem. Abstr., 102, 158254 (1984). See also A. Isenberg, B. Kruecke, G. Pelzl, H. Zaschke and D. Demus, Cryst. Res. Technol., 18, 1059 (1983); G. Pelzl, H. Zaschke and D. Demus, Displays, 6, 141 (1985); D. Demus, A. Isenberg, G. Pelzl, B. Kruecke and H. Zaschke, German Patent DD 151950; Chem. Abstr., 97, 14855 (1982); D. Demus, H. Zaschke, G. Pelzl, H. Enzenberg and A. Isenberg, German Patent DE 3408042A1; Chem. Abstr., 102, 158242 (1985); Hitachi, Japanese Patent JP 8388371A2, 5888371; Chem. Abstr., 99, 139973 (1983); Sanyo, Japanese Patent JP 81116775 A2; Chem. Abstr., 96, 1333269 (1982); Chisso, Japanese Patent JP 8214584; Chem. Abstr., 96, 217890 (1982); Chisso Corporation, Japanese Patent JP 8192879A2; Chem. Abstr., 96, 77607 (1982); Sharp Corporation, Japanese Patent JP 8162874A2; Chem. Abstr., 96, 60880 (1982); Chisso Corporation, Japanese Patent JP 818348A2; Chem. Abstr., 96, 35318 (1982); Chisso Corporation, Japanese Patent JP 8190072A2; July 21, 1981; Chem. Abstr., 96, 13649 (1982); H. Schubert, D. Demus, H. Zaschke, F. Kuschel, G. Pelzl, H. Nothnik and W. Schliemann, U. S. Patent 4358589A; Chem. Abstr., 98, 73840 (1983); H. Zaschke, R. Wolff, G. Pelzl and D. Demus, U. S. Patent 4348298A; Chem. Abstr., 97, 227633 (1982); D. Alvarez, G. Bjorklund and D. Burland, U. S. Patent 4339513A; Chem. Abstr., 97, 153950 (1982).

216. N. Azuma, H. Ohya-Nishiguchi, J. Yamauchi, K. Mukai and Y. Deguchi, Bull. Chem. Soc. Jpn., 47, 2369 (1974).

217. I. Brown and R. Kreilick, J. Chem. Phys., 62, 1190 (1975).

218. O. Polumbrik, A. Nesterenk and L. Markovskii, Dokl. Akad. Nauk SSR, 240, 640 (1978).

219. W. Vollmann, Mol. Phys., 32, 395 (1976); F. Neugebauer and R. Siegel, Chem. Ber., 118, 2157 (1985); W. Kaim, S. Ernst, S. Kohlmann and P. Welk-

erling, Chem. Phys. Lett., 118, 431 (1985).

220. M. Higashi and H. Yamaguchi, J. Heterocycl. Chem., 13, 1343 (1976).

221. R. Hochstrasser, D. King and A. B. Smith, III, J. Am. Chem. Soc., 99, 3923 (1977).

222. O. Polumbrik, A. Nesterenko and L. Markovskii, Dopov. Akad. Nauk Ukr. RSR, Ser. B, Geol., Khim, Biol. Nauki, 521 (1977); see as well A. Nesterenko, O. Polumbrik and L. Markovskii, ibid., 40 (1982); A. Nesterenko, O. Polumbrik, I. Ryabokon and L. Markovakii, Zh. Obshch. Khim., 54, 1330 (1984).

223. H. DeVries and D. Wiersma, Phys. Rev. Lett., 36, 91 (1976).

224. H. DeVries and D. Wiersma, Chem. Phys. Lett., 51, 565 (1977); for a related study, see also H. DeVries and D. Wiersma, J. Chem. Phys., 72, 1851 (1980).

225. L. Degtyarev and V. Pokhodenko, Teor. Eksp. Khim., 15, 88 (1979).

226. U. Boesl, H. Neusser and E. Schlag, Chem. Phys. Lett., 61, 57 (1979).

227. R. Hochstrasser and D. King, J. Am. Chem. Soc., 98, 5443 (1976).

228. J. DeVries, D. Bebelaar and J. Langelaar, Opt. Commun., 18, 24 (1976); see also J. Ramaekers, H. van Dijk, J. Langelaar and R. Rettschnick, Faraday Discuss. Chem. Soc., 183 (1983); J. Ramaekers, L. Krijnen, H. Lips, J. Langelaar and R. Rettschnick, Laser Chem., 2, 1 (1983); J. Langelaar, D. Bebelaar and R. Rettschnick, NATP ASI Ser., Ser. C, 127, 293 (1984); J. Langelaar and R. Rettschnick, Ned. Tijdschr. Natuurkd., A, A50, 15 (1984).

229. D. Esquivel, M. de Giambiagi and S. Makler, Chem. Phys. Lett., 64, 131 (1979).

230. V. Savushkina, Izv. Vyssh. Uchebn. Zaved., Fiz., 18, 155 (1975).

231. M. Mahanti, Indian J. Chem., Sect. B, 15B, 168 (1977).

232. M. Dewar, Pure Appl. Chem., 44, 767 (1975).

233. L. Asbrink, C. Fridh and E. Lindholm, NATO Adv. Study Inst. Ser., Ser. C, 8, 247 (1974).

234. K. van der Meer and J. Mulder, Theor. Chim. Acta, 41, 183 (1976).

235. D. Mukherjee, Chem. Phys. Lett., 79, 559 (1981); Y. Kawaguchi and R. Mann, Spectrochim. Acta, Part A, 31A, 979 (1975); S. Adnan, S. Bhattacharya and D. Mukherjee, Mol. Phys., 39, 519 (1980); cf. K. Mukai, T. Yamamoto, M. Kohno, N. Azuma and K. Ishizu, Bull. Chem. Soc. Jpn., 47, 1797 (1974).

236. J. Glownia and S. Riley, Chem. Phys. Lett., 71, 429 (1980); D. Bur-

land and F. Carmona, Mol. Cryst. Liq. Cryst., 50, 279 (1979).

237. D. Coulter, D. Dows, H. Reisler and G. Wittig, Chem. Phys., 32, 429 (1978).

238. B. Dellinger, M. Paczkowski, R. Hochstrasser and A. B. Smith, III, J. Am. Chem. Soc., 100, 3242 (1978).

239. D. Burland, F. Carmona and J. Pacansky, Chem. Phys. Lett, 56, 221 (1978).

240. D. King, C. Denny, R. Hochstrasser and A. B. Smith, III, J. Am. Chem. Soc., 99, 271 (1977). In a related area, see E. Cuellar and G. Castro, Chem. Phys., 54, 217 (1981).

241. M. Paczhowski, R. Pierce, A. B. Smith, III, and R. Hochstrasser, Chem. Phys. Lett., 72, 5 (1980); H. Ito and Y. Ihaya, Bull. Chem. Soc. Jpn., 49, 940 (1976).

242. M. Semmelhack, H. Weller and J. Clardy, J. Org. Chem., 43, 3791 (1978).

243. A. Watkins, J. Chem. Phys., 83, 1892 (1979).

244. H. Gotthardt and F. Reiter, Chem. Ber., 112, 1635 (1979).

245. G. Neikov and N. Tyutyulkov, Izv. Khim., 12, 27 (1979); A. Melezhik, L. Ganyuk and V. Pokhodenko, Teor. Eksp. Khim., 15, 314 (1979); V. Berezin and M. Sverdlov, Opt. Spektrosk., 58, 1242 (1985); J. Ramaekers, J. Langelaar and R. Rettschnick, Springer Ser. Chem. Phys., 23, 264 (1982); G. Marconi and V. Raffaelli, Theochem., 14, 259 (1983); H. Vogler and F. Neugebauer, Z. Naturforsch., B: Anorg. Chem., Org. Chem., 39B, 1790 (1984); V. Berezin, N. Bogachev and M. Sverdlov, Zh. Prikl. Spektrosk., 43, 681 (1985).

246. T. Malloy, Jr., and L. Carreira, J. Chem. Phys., 68, 2674 (1978). H. Thijssen, R. van den Berg and S. Voelker, Chem. Phys. Lett., 97, 295 (1983); S. Ghosh and M. Chowdhury, ibid., 85, 233 (1982); G. Asmuth, Diss. Abstr. Int. B, 44, 3416 (1984); G. Asmuth and K. Innes, J. Mol. Spectrosc., 103, 495 (1984); K. Watson, Diss. Abstr. Int. B, 44, 3088 (1984); D. Mordaunt, Diss. Abstr. Int. B, 44, 511 (1983); M. Paczkowski, Diss. Abstr. Int. B, 44, 814 (1983); D. Levy, C. Haynam and D. Brumbaugh, Faraday Discuss. Chem. Soc., 137 (1983); M. Newcomb and M. Burchill, J. Am. Chem. Soc., 105, 7759 (1983); Y. Park and D. Levy, J. Chem. Phys., 81, 5527 (1984); C. Haynam and D. Levy, J. Ohys. Chem., 87, 2091 (1983); L. Young, C. Haynam and D. Levy, Jersualem Symp. Quantum Chem. Biochem., 15, 219 (1982); C. Haynam, L. Young, C. Morter and D. Levy, J. Chem. Phys., 81, 5216 (1984); D. Smith, A. Lorincz, J. Siemion and S. Rice, ibid., 81, 2295 (1984); C. Haynam, D. Brumbaugh and D. Levy, ibid., 81, 2282 (1984); C. Haynam, D. Brumbaugh and D. Levy, ibid., 81, 2270 (1984); C. Haynam, D. Brumbaugh and D. Levy, ibid., 80, 2256 (1984); L. Young, C. Haynam and D. Levy, ibid., 79, 1592 (1983); L. Young, C. Haynam and D. Levy, Jerusalem Symp. Chem. Biochem., 15,219, (1982); C. Haynam, D. Brumbaugh and D. Levy, J. Chem. Phys., 79, 1581 (1983); D. Brumbaugh,

J. Kenny and D. Levy, ibid., 78, 3415 (1983); K. Innes, ibid., 76, 2100 (1982); D. Brumbaugh, C. Haynam and D. Levy, J. Mol. Spectrosc., 94, 316 (1982).

247. M. Paddon-Row, H. Patney and R. Warrener, J. Org. Chem., 44, 3908 (1979).

248. S. Ito, A. Kakehi, Y. Tanaka, K. Yoshida and T. Matsuno, Bull. Chem. Soc. Jpn., 52, 483 (1979).

249. M. Paddon-Row, H. Patney and R. Warrener, Chem. Commun., 296 (1978).

250. H. Fuehlhuber and J. Sauer, Tetrahedron Lett., 4393 (1977).

251. G. Seitz and T. Kaempchen, Chem. Ztg., 99, 503 (1975).

252. N. Reinhoudt and C. Kouwenhoven, Recl. Trav. Chim. Pays-Bas, 93, 321 (1974); K. Sugiyama, Kinki Daigaku Kogakubu Kenkyu Hokoku, 17, 15 (1983); Chem. Abstr., 101, 190947 (1984).

253. H. Fuehlhuber, C. Gousetis, J. Sauer and H. Lindner, Tetrahedron Lett., 1299 (1979); H. Fuehlhuber, C. Gousetis, T. Troll and J. Sauer, Tetrahedron Lett., 3903 (1978).

254. Y. Shermolovich, A. Misyura, O. Polumbrik and L. Markovskii, Akad. Nauk Ukr. RSR, Ser. B, Geol., Khim., Biol. Nauki, 449 (1979); Chem. Abstr., 91, 140014 (1979).

255. O. Polumbrik and E. Zaika, Org. React. (Tartu), 14, 388 (1977).

256. O. Polumbrik and E. Zaika, ibid., 14, 375 (1977).

257. F. Neugebauer and H. Fischer, Tetrahedron Lett., 3345 (1977).

258. V. Premyslov and E. Ponomareva, Ukr. Khim. Zh., 42, 510 (1976).

259. O. Polumbrik, E. Zaika and G. Dvorko, ibid., 40, 963 (1974).

260. O. Polumbrik and E. Zaika, Dopov. Akad. Nauk Ukr. RSR, Ser. B, 338 (1975).

261. O. Polumbrik and E. Zaika, Reakts. Sposobn. Org. Soedin., 11, 391 (1974).

262. O. Polumbrik, N. Vasilkevich and G. Dvorko, Zh. Org. Khim., 11, 770 (1975).

263. V. Premyslov and E. Ponomareva, Dopov. Akad. Nauk Ukr. RSR, Ser. B, 447 (1975).

264. O. Polumbrik, N. Vasilkevich and G. Dvorko, Ukr. Khim. Zh., 40, 1161 (1974).

265. O. Polumbrik, E. Zaika and G. Dvorko, Zh. Org. Khim., 10, 1953 (1974).

266. M. Sytilin, Ukr. Khim. Zh., 45, 676 (1979).

267. A. Mozorov and M. Sytilin, Zh. Org. Khim., 14, 2471 (1978).

268. M. Sytilin, Deposited Doc., VINITI, 1498 (1977); Chem. Abstr., 90, 103183 (1979).

269. O. Polumbrik, Zh. Obshch. Khim., 47, 2396 (1977).

270. M. Sytilin, Zh. Fiz. Khim., 51, 2128 (1977).

271. M. Sytilin, ibid., 51, 266 (1977).

272. M. Sytilin, ibid., 51, 235 (1977).

273. E. Zaiba, B. Yarmolyuk and O. Polumbrik, Tezisy Dokl.-Ukr. Resp. Konf. Org. Khim., 12 (1973).

274. M. Sytilin, Zh. Fiz. Khim., 50, 1306 (1976).

275. O. Polumbrik, V. Staninets and B. Yarmolyuk, Reacts. Sposobn. Org. Soedin., 12, 161 (1975).

276. O. Polumbrik, Y. Serguchev and N. Vasilkevich, Zh. Obshch. Khim., 46, 160 (1976).

277. O. Polumbrik, E. Zaika and B. Yarmolyuk, Reacts. Sposobn. Org. Soedin., 12, 111 (1975).

278. O. Polumbrik, B. Yarmolyuk and E. Zaika, Zh. Fiz. Khim., 49, 742 (1975).

279. O. Polumbrik and B. Yarmolyuk, Neftekhimiya, 15, 306 (1975).

280. B. Yarmolyuk, O. Polumbrik and G. Dvorko, ibid., 14, 755 (1974).

281. G. Dvorko, E. Ponomareva and P. Tarasenko, Dokl. Akad. Nauk RSR, 235, 1312 (1977).

282. E. Ponomareva, P. Tarasenko and G. Dvorko, Dopov. Akad. Nauk Ukr. RSR, Ser. B, 142 (1977).

283. P. Tarasenko, E. Ponomareva, G. Dvorko and E. Babin, Reakts. Sposobn. Org. Soedin., 13, 5 (1976).

284. P. Tarasenko, E. Ponomareva and E. Babii, Vestn. Kiev. Politekhn. Inta. Ser. Khim. Mashinostr. i Tekhnol., 36 (1976); Ref. Zh. Khim., Abstr. No. 3B995 (1977); Chem. Abstr., 86, 188736 (1977).

285. E. Ponomareva, P. Tarasenko and G. Dvorko, Tetrahedron Lett., 1893 (1976).

286. N. Kulik, E. Ponomareva and G. Dvorko, Zh. Obshch. Khim., 45, 2077 (1975).

287. N. Kulik, E. Ponomareva and G. Dvorko, Teor. Eksp. Khim., 11, 235 (1975).

288. E. Ponomareva, N. Kulik and G. Dvorko, Reakts. Sposobn. Org. Soedin, 11, 333 (1974).

289. H. Eger, A. Rieker and E. Mueller, Tetrahedron, 32, 2579 (1976).

290. N. Nishimura and N. Itakura, Australian J. Chem., 30, 221 (1977).

291. C. Mao and R. Kreilick, Mol. Phys., 31, 1447 (1976).

292. Y. Miura, Y. Morimoto and M. Kinoshita, Bull. Chem. Soc. Jpn., 48, 3765 (1975).

293. A. Maquestiau, Y. van Haverbeke, R. Flammaug, R. Huisgen and Y. Chae, Bull. Soc. Chim. Belg., 84, 1179 (1979).

294. S. Nelsen. P. Hintz, J. Buschek and G. Weisman, J. Am. Chem. Soc., 97, 4933 (1975).

295. V. Koshechko, Y. Atamanyuk and V. Pokhodenko, Teor. Eksp. Khim., 13, 755 (1977).

296. V. Pokhodenko and V. Khizhnyi, V. sb., XI Mendeleevsk. sezd op. Obshch. i Prikl. Khimii. Ref. Kodl. i Soobshch., 199 (1975); Ref. Zh. Khim., Abstr. No. 3B1313 (1976); Chem. Abstr., 84, 179326 (1976).

297. V. Pokhodenko, V. Khizhnyi and V. Smarskii, Teor. Eksp. Khim., 11, 674 (1975).

298. V. Pokhodenko, V. Khizhnyi, V. Koshechko and V. Samarskii, ibid., 11, 579 (1975).

299. A. Sidyakin, O. Polumbrik, G. Dvorko and E. Ponomareva, Reakts. Sposobn. Org. Soedin., 11, 35 (1974).

300. F. Neugebauer, R. Bernhardt and H. Fischer, Chem. Ber., 110, 2254 (1977). For a study of field-induced color change, see G. Pelzl, H. Schubert, H. Zaschke and D. Demus, Cryst. Res. Technol., 817 (1979).

301. R. Spagna and A. Vaciago, Acta Crystallogr., Sect. B, B34, 993 (1978).

302. M. Caira, R. Giles, L. Nassimbeni, G. Sheldrick and R. Hazell, ibid., B32, 1467 (1976).

303. H. Govers, Acta Crystallogr., Sect. A, A31, 380 (1975).

304. G. Ansell and J. Erickson, J. Chem. Soc., Perkin Trans. 2, 270 (1975); J. Huffman, Cryst. Struct. Commun., 10, 227 (1981).

305. G. Kothe and E. Ohmes, Ber. Bunsenges. Phys. Chem., 78, 924 (1974).

306. N. Azuma, Y. Deguchi, F. Marumo and Y. Saito, Bull. Chem. Soc. Jpn., 48, 819 (1975).

307. N. Azuma, Y. Deguchi, F. Marumo and Y. Saito, ibid., 48, 825 (1975).

308. ICI, Netherlands Patent Appl., 7513223; Chem. Abstr., 88, 46371 (1978).

309. V. Fomenko, N. Geona, V. Lipnitskii, O. Shvaika, G. Kondratenko and S. Baranov, Fiziol. Akt. Veshchestva, 7, 64 (1976); Chem. Abstr., 83, 188770 (1975).

310. K. Pilgram, L. Wittsell, R. Skiles, A. James and J. Dawson, J. Agric. Food Chem., 25, 888 (1977).

311. C. Wasternack and H. Reinbothe, Plant Sci. Lett., 9, 171 (1977).

312. R. Blecher, U. Koch, B. Ballhouse and F. Ungens, Z. Pflanzenkr. Pflanzenschutz, 86, 93 (1979).

313. K. Rainsford, Agents Actions, 8, 587 (1978).

314. S. Lang, Jr., B. Johnson, E. Cohen, A. Sloboda and E. Greenblatt, J. Med. Chem., 19, 1404 (1976).

315. I. Postovskii, V. Ershov, E. Sidorov and N. Serebryakova, Khim. Geterotsikl. Soedin., 1564 (1977).

316. A. von Koenig, H. Odenwalder, M. Peters and W. Pueschel, U. S. Patent 4139387; Chem. Abstr., 91, 30509 (1979).

317. A. von Koenig, H. Odenwalder, P. Manfred and W. Pueschel, German Patent 2746965; Chem. Abstr., 91, 66276 (1979).

318. Anon., Res. Discl., 157, 54 (1977); Chem. Abstr., 87, 60694 (1977).

319. R. Hochstrasser and D. King, Lasers Phys. Chem. Biophys., Proc. Int. Mtg. Soc. Chem. Phys., 177 (1975); Chem. Abstr., 84, 157964 (1976).

320. D. Burland and D. Haarer, IRM J. Res. Dev., 23, 534 (1979).

321. D. Burland, Proc. Soc. Photo-Opt. Instrum. Eng., 113, 151 (1977).

322. B. Dellinger, D. King, R. Hochstrasser and A. B. Smith, III, J. Am. Chem. Soc., 99, 7138 (1977).

323. B. Dellinger, D. King, R. Hochstrasser and A. B. Smith, III, ibid., 99, 3197 (1977).

324. L. Ganyuk, A. Melezhik and V. Pokhodenko, Teor. Eksp. Khim., 12, 254 (1976).

325. R. Hochstrasser and D. King, Proc. Tech. Program---Electro-Opt. System Des. Conf. Int. Laser Expo, 185 (1975); Chem. Abstr., 85, 199771 (1976).

326. R. Karl, Jr., and K. Innes, Chem. Phys. Lett., 36, 275 (1975).

327. R. Hochstrasser and D. King, J. Am. Chem. Soc., 97, 4760 (1975).

328. H. Schubert, G. Pelzl, H. Zaschke, D. Demus, H. Nothnik and F. Kuschel, German Patent DE 2841246; Chem. Abstr., 91, 184980 (1979); G. Pelzl, A. Hauser, H. Kresse and D. Demus, Krist. Tech., 15, 1345 (1980); D. Demus, B. Kruecke, F. Kuschel, H. Nothnik, G. Pelzl and H. Zaschke, Mol. Cryst. Liq. Cryst., 56, 115 (1979).

329. A. Feheravi, T. Foldes-Berezhnykh and F. Tudos, Magy. Kem. Foly., 85, 205 (1979).

330. S. Gudzera, S. Verbovaya, A. Rudko and P. Datso, USSR Patent SU 637773; Chem. Abstr., 90, 122548 (1979).

331. S. Gudzera, V. Rosovitskii, P. Datso, A. Karnaukh and V. Magdinets, Vysokomol. Soedin., Ser. A, 21, 457 (1979).

332. L. Surovtsev, V. Kiselev, V. Dvortsov, V. Volnukhim and N. Khizhnyak, ibid., 21, 1660 (1979).

333. T. Yamazaki, K. Ishihara, K. Matsumoto and S. Oya, Kyoto Kogei Seni Daigaku Senigakakubu Gakujutsu Hokoku, 8, 35, (1978); Chem. Abstr., 90, 204925 (1979).

334. L. Pritykin and V. Orlov, USSR Patent SU 600162; Chem. Abstr., 88, 192374 (1978).

335. M. Sytilin and A. Morozov, Zh. Fiz. Khim., 52, 2933 (1978).

336. A. Buckley, E. Gazzard, J. Greenshields, D. Pemberton, J. Wild and D. Leitch, British Patent 1531717; Chem. Abstr., 91, 92241 (1979).

337. A. Misyura, O. Polumbrik, M. Lozinskii and L. Markovskii, Dopov. Akad. Nauk Ukr. RSR, Ser. B, Geol., Khim., Biol. Nauki, 1103 (1976).

338. I. Beletskaya, E. Tomilenko, N. Kamenichnaya, V. Staninets, Zh. Gorbatenko and N. Feshchenko, Khim. Elementoorg. Soedin., 170 (1976).

339. A. Misyura, V. Magclinets and Y. Spirin, Sint. Fiz.-Khim. Polim., 16, 10 (1975).

340. M. Imoto, Y. Nakamura and T. Ouchi, Bull. Chem. Soc. Jpn., 48, 1280 (1975).

341. V. Tertykh, L. Degtyarev, V. Ogenko and A. Tropinov, Dopov. Akad. Nauk Ukr. RSR, Ser. B, 633 (1975).

342. E. Reinsh, Mol. Phys., 28, 683 (1974).

343. H. Kato, Japanese Patent 7447439; Chem. Abstr., 82, 44695 (1975).

344. F. Harris, S. Norris, L. Lanier and W. Feld, Am. Chem. Soc., Div. Org. Coat. Plast. Chem., Pap., 33, 160 (1973).

345. Y. Miura, Y. Morimoto and M. Kinoshita, Makromol. Chem., 175, 3487 (1974); K. Sugiyama, M. Tanaka and M. Kuwabara, Kinki Daigaku Kogakubu Kenkyu Hokoku, 17, 27 (1983); Chem. Abstr., 101, 171805 (1984).

346. K. Konishi, A. Kotone, Y. Nakane, T. Hori and M. Hoda, U. S. Patent 3951941; Chem. Abstr., 85, 79678 (1976).

347. A. Kotone, M. Hoda, T. Fujita and T. Hori, Japanese Patent 7528526; Chem. Abstr., 83, 81204 (1975).

348. A. Kotone, M. Hoda, T. Fujita and T. Hori, Japanese Patent 7534029; Chem. Abstr., 83, 195215 (1975).

349. A. Kotone, Y. Nakane, M. Hoda, T. Hori and K. Konishi, Japanese Patent 74117525; Chem. Abstr., 82, 157822 (1975).

350. C. Seliskar and M. Leugers, Chem. Phys. Lett., 111, 141 (1984); K. Innes, D. Brumbaugh and L. Franks, Chem. Phys., 59, 439 (1981); D. Brumbaugh, C. Haynam and D. Levy, J. Chem. Phys., 73, 5380 (1980); J. Kenny, D. Brumbaugh and D. Levy, ibid., 71, 4757 (1979); D. Levy, C. Haynam, L. Young and D. Brumbaugh, Electron. At. Collisions, Invited Pap. Int. Conf. Phys. Electron. At. Collisions, 13, 617 (1984). For further details, see D. Brumbaugh, Diss. Abstr. Int. B, 41, 2192 (1980).

351. J. Parsons and P. West, European Patent Appl. EP 29657; Chem. Abstr., 95, 169230 (1981); J. Parsons, European Patent Appl. EP 5912; Chem. Abstr., 93, 46730 (1980); J. Parson and P. West, European Patent Appl. EP 36711A2; Chem. Abstr., 96, 69002 (1982); K. Bryan, Q. Geering and J. Reid, Proc. Br. Crop Prot. Conf.-Pests Dis., 11, 67 (1981); Anon., Res. Discl., 251, 133 (1985); Anon., ibid., 233, 284 (1983); Anon., ibid., 218, 198 (1982); Anon., ibid., 211, 420 (1981).

352. A. Kazymov, N. Shvink and S. Lerner, Izv. Sib. Otd. Akad. Nauk SSSR, Ser. Khim. Nauk, 91 (1980); Chem. Abstr., 93, 34854 (1980).

353. C. Braeuchle, D. Burland and G. Bjorklund, J. Am. Chem. Soc., 103, 2515 (1981); G. Bjorklund, D. Burland and D. Alvarez, J. Chem. Phys., 73, 4321 (1980). Cf. D. Alvarez, G. Bjorklund and D. Burland, European Patent Appl., EP 44457; Chem. Abstr., 96, 172190 (1982).

354. T. Malloy and L. Carreira, J. Chem. Phys., 71, 2488 (1979); M. Leugers and C. Seliskar, J. Comput. Chem., 5, 457 (1984); M. Heppener, A. Kunst, D. Bebelaar and R. Rettschnick, J. Chem. Phys., 83, 5341 (1985).

355. G. Asmuth, K. Innes and V. Job, J. Mol. Spectrosc., 83, 266 (1981).

356. J. Pacansky and H. Coufal, J. Phys. Chem., 84, 3238 (1980).

357. G. Naray-Szabo and P. Surjan, J. Signalaufzeichnungsmaterialien, 8,

445 (1980).

358. S. Mathur, K. Roy and B. Kumar, Proc. Nucl. Phys. Solid State Phys. Symp., 21C, 181 (1978); cf. G. Korany, E. Szebenyi-Gyori, A. Velin-Prikidanovics and J. Brlik, Acta Chim. Hung., 116, 131 (1984); M. Hanack, A. Datz, R. Fay, K. Fischer, C. Hedtmann-Rein, U. Keppeler, J. Koch and W. Stoeffler, Polym. Prepr., 25, 232 (1984); O. Schneider and M. Hanack, Angew. Chem., 95, 804 (1983); X. Wang, F. Wang, W. Gu and C. Gu, Taiyangneng Xuebao, 3, 233 (1982); Chem. Abstr., 98, 19384 (1983); C. Gu and W. Gu, New Front. Organomet. Inorg. Chem. Proc. China-Jpn-USA Trilateral Semin., 2, 3, (1984); Chem. Abstr., 102, 140586 (1985).

359. J. Langelaar, D. Bebelaar, M. Leeuw, J. Ramaekers and R. Rettschnick, Springer Ser. Chem. Phys., 14, 171 (1980); U. Boesl, H. Neusser and E. Schlag, ibid., 6, 290 (1979).

360. M. Ohsaku, S. Shigemi, H. Murata and A. Imamura, Tetrahedron, 37, 297 (1981).

361. H. Tam and D. Quan, Toxicol. Eur. Res., 1, 321 (1978).

362. W. Schliemann, Z. Chem., 20, 374 (1980).

363. V. Zverev, B. Buzykin and V. Ivanova, Zh. Obshch. Khim., 49, 1839 (1979).

364. S. Kohlmann, S. Ernst and W. Kaim, Angew. Chem., 97, 698 (1985).

365. I. Shegal, N. Matveeva and L. Shegal, Depos. Doc., SPSTL 432Khp-D80 (1980).

366. T. Troll, Electrochim. Acta, 27, 1311 (1982).

367. AIST Japan, Japanese Patent JP 8538461A2, 6038461; Chem. Abstr., 103, 133308 (1985); AIST Japan, Japanese Patent JP 8538463A2, 6038463; Chem. Abstr., 103, 133306 (1985).

368. Sanyo, Japanese Patent JP 8295392A2; Chem. Abstr., 97, 184235 (1982).

369. E. Rothgery and R. Scott, U. S. Patent 4389327A; Chem. Abstr., 99, 163814 (1983).

370. N. Johnson, C. Gotzmer and M. Graff, U. S. Patent Appl. 351711AO; Chem. Abstr., 97, 165540 (1982).

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