*Fourth International Electronic Conference on Synthetic Organic Chemistry (ECSOC-4), www.mdpi.org/ecsoc-4.htm, September 1-30, 2000*

---

[A0003]

# 3-Dimethylaminopropenoates and Related Compounds in the Synthesis of Heterocyclic Systems and Heterocyclic Amino Acids

Branko Stanovnik

Faculty of Chemistry and Chemical Technology, University of Ljubljana, Askerceva 5, P. O. Box 537, 1000 Ljubljana, Slovenia
E-mail: branko.stanovnik@uni-lj.si

*Received: 2 August 2000 / Uploaded: 3 August 2000*

---

**Contents**

**1**. Introduction

**2**. Synthesis of 2-acylamino-3-dimethylaminopropenoates, *O*-substituted 2-hydroxy-3-dimethylaminpopropenoates and 2-[(2-substituted ethenyl)amino-3-dimethylaminopropenoates

**3**. Synthesis of heterocyclic systems

*3.1* Synthesis of pyranones and fused pyranones

*3.2* Synthesis of fused pyridinones

*3.3* Synthesis of fused pyrimidinones

*3.4* Synthesis of pyrroles

3.4.1 Substituted 3-aminopyrrole-2,4-dicarboxylates

3.4.2 Pyrrole-2-carboxylates

*3.5* Synthesis of imidazolecarboxylates

*3.6* Synthesis of pyrazoles

*3.7* Synthesis of 1,2,4-oxadiazoles

*3.8* Synthesis of aplysinopsins and azaaplysinopsins

**4**. Synthesis and transformations of chiral 3-dimethylaminopropenoates

*4.1* A one-step synthesis of (*S*)-3-heteroarylalanines

*4.2* Synthesis 3-heteroaryl substituted lactates

**5**. References and notes

## 1. Introduction

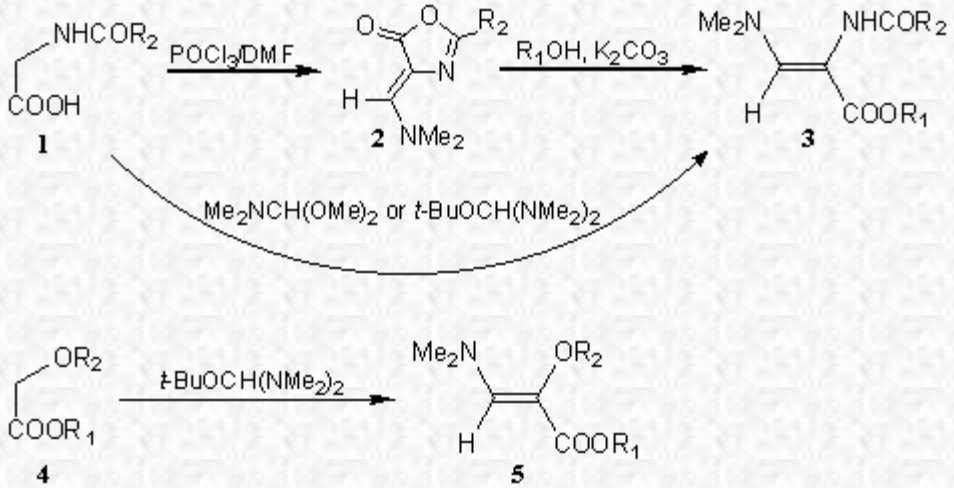
a -Amino and a -hydroxy acids and their derivatives play an important role in organic synthesis, especially in asymmetric synthesis as chiral synthons, chiral auxiliaries, and resolving agents [1-3].

In the course of our studies of heteroaryl substituted a -amino and a -hydroxy acids and their derivatives we have prepared easily accessible 2-acylamino-3-dimethylaminopropenoates, 2-(*O*-substituted hydroxy)-3-dimethylaminopropenoates, and 2-ethenylamino-3-dimethylaminopropenoates, masked a -formyl-a -amino- and a -formyl-a -hydroxy acids, and their derivatives. They have turned out to be excellent reagents for the preparaton of a variety of heterocyclic systems with an amino or hydroxy acid structural element incorporated or partially incorporated into the newly formed heterocyclic ring [4]

## 2. Synthesis of 2-acylamino-3-dimethylaminopropenoates, *O*-substituted 2-hydroxy-3-dimethylaminpopropenoates and 2-[(2-substituted ethenyl)amino-3-dimethylaminopropenoates.

Alkyl 2-acylamino-3-dimethylaminopropenoates (**3**) can be prepared by two methods: a) by reaction of N-acylglycine (**1**) with phosphorus oxychloride in N,N-dimethylformamide to afford 4-dimethylaminomethylidene-5(4*H)*-oxazolone (**2**) followed by alcoholysis in the presence of potassium carbonate to give **1**, or b) by treatment of **1** with *N,N*-dimethylformamide dimethyl acetal or *t*-BuOCH($NMe_2$) to give **1** in one pot procedure. Similarly, alkyl *O*-substituted 2-hydroxyacetates (**4**) when treated with *tert*-butyloxy-*bis*(dimethylamino)methane to give **5.** (Scheme 1).

**Scheme 1: Synthesis of 2-acylamino- and *O*-substituted 2-hydroxy-3-dimethylaminopropenoates.**

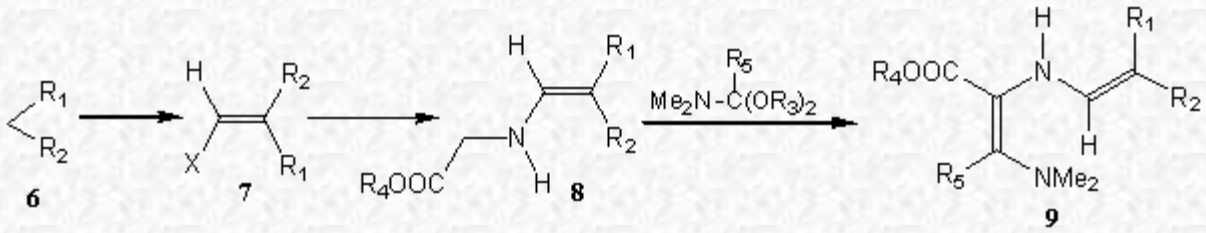



| | $R_1$ | $R_2$ | Ref. |
|---|---|---|---|
| **3a** | Me | Ph | 5,6 |
| **3b** | Et | Ph | 7 |
| **3c** | Me | Me | 8 |

| | | | |
|---|---|---|---|
| **3d** | Et | Me | 9 |
| **3e** | Me | $CF_3$ | 8 |
| **3f** | Me | $OCH_2Ph$ | 10 |
| **5a** | Me | COPh | 11 |
| **5b** | Et | COPh | 11 |
| **5c** | Me | $CH_2Ph$ | 11 |
| **5d** | Me | Ph | 11 |

2-[(2-Substituted ethenyl)amino]-3-dimethylaminopropenoates (**9**) can be prepared from compounds with an active methylene group **6** by transformation into ethoxymethylidene- or dimethylaminomethylidene derivatives **7**. These are with an alkyl glycinate into **8** and further with *N*,*N*-dimethylformamide dimethyl acetal into **9**. (Scheme 2).

**Scheme 2: Synthesis of 2-[(2-substituted ethenyl)amino]-3-dimethylaminopropenoates.**




| **9** | **$R_1$** | **$R_2$** | **$R_3$** | **$R_4$** | **$R_5$** | **Ref.** |
|---|---|---|---|---|---|---|
| a | COOEt | COOEt | H | Me | H | 12 |
| b | COOEt | COOEt | H | Et | H | 13 |
| c | COOMe | COOMe | H | Et | H | 14 |
| d | COOEt | COPh | H | Me | H | 15 |
| e | COOEt | COPh | H | Et | H | 15 |
| f | COOEt | COMe | H | Me | H | 16 |
| g | COOMe | COMe | H | Me | H | 17 |
| h | COPh | COPh | H | Et | H | 18 |
| i | COMe | COPh | H | Et | H | 19 |
| j | COMe | COMe | H | Me | H | 20 |

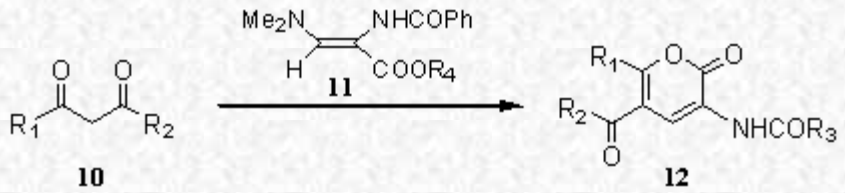
| | | | | | | |
|---|---|---|---|---|---|---|
| k | COOBn | COMe | H | Me | H | 17 |
| l | COOEt | Ph | H | Me | H | 21 |
| m | COOEt | CN | H | Et | H | 22,23 |
| n | COOEt | CN | Me | Me | H | 23 |
| o | COOEt | CN | Me | Et | H | 23 |
| p | COOEt | COOEt | H | Me | Me | 24 |

**3. Synthesis of heterocyclic systems**

2-Acylamino- and *O*-substituted 2-hydroxy-3-dimethylaminopropenoates and their derivatives can be applied as three carbon synthons for the synthesis of a variety of monocyclic and polycyclic heterocyclic systems, in which a -amino- or a -hydroxy acid structural element is incorporated into the heterocyclic system.

**3.1 Synthesis of pyranones and fused pyranones**

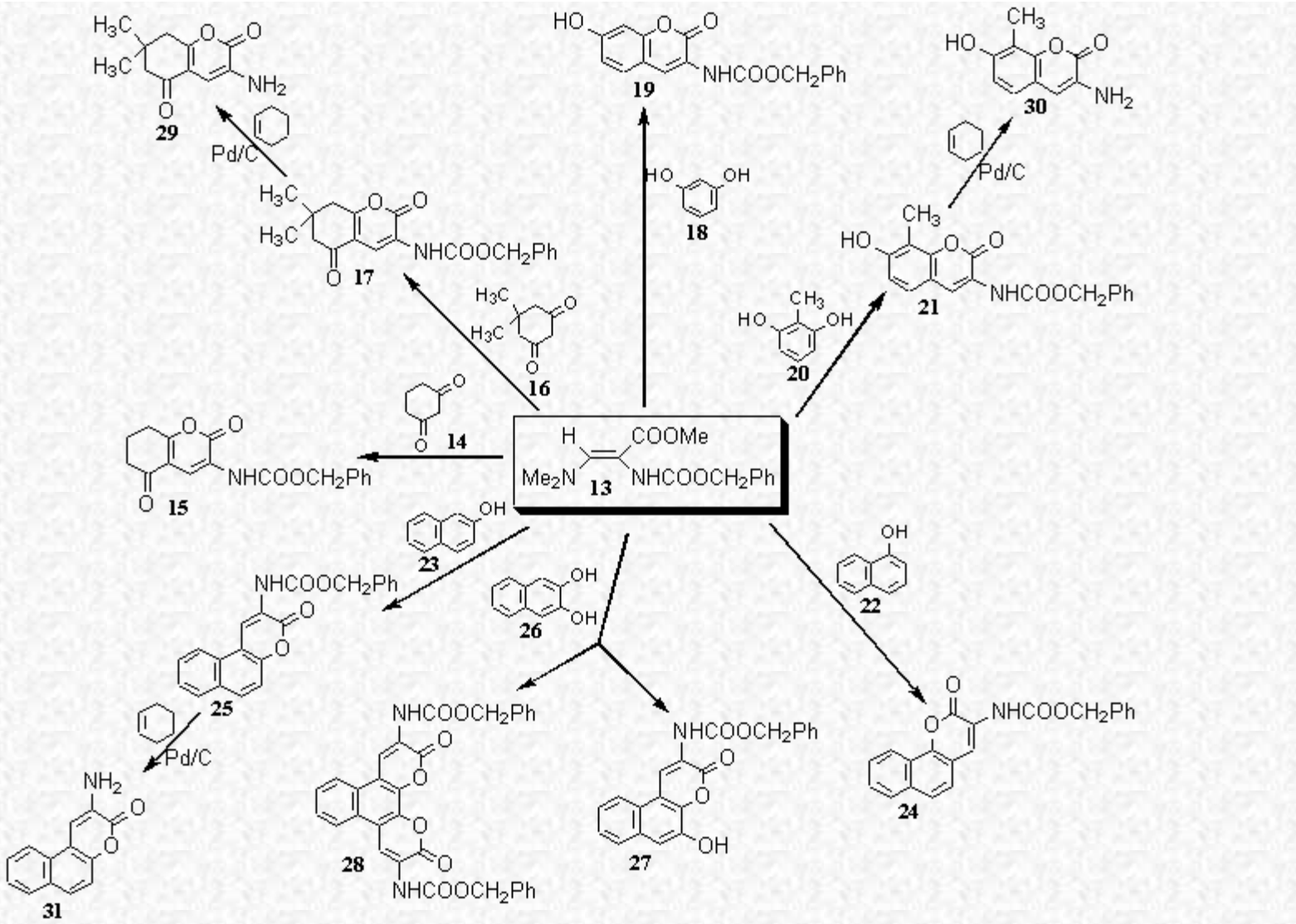
**Scheme 3: Synthesis of pyranones**




| | | | | |
|---|---|---|---|---|
| $R_1$ | Ph | Me | Me | Me |
| $R_2$ | OEt | OEt | Ph | Me |

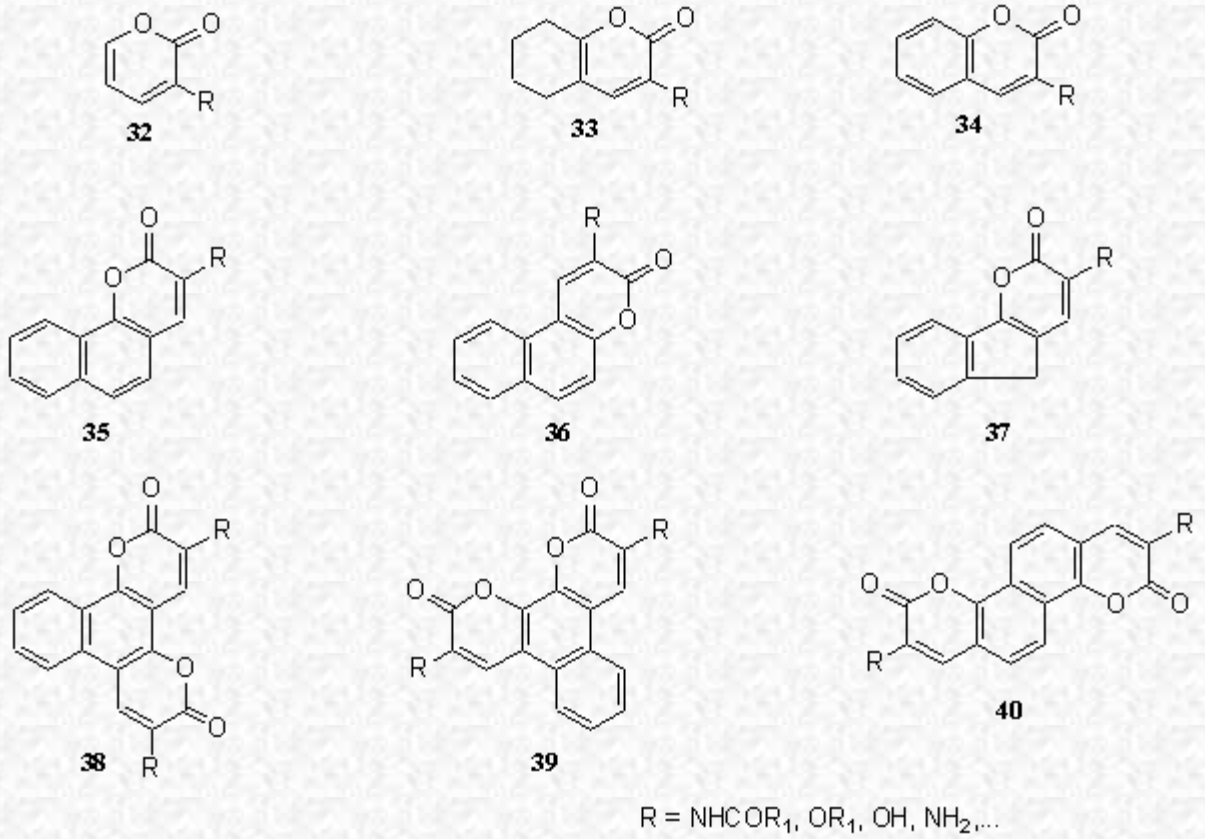
In the reaction of 1,3-dicarbonyl compounds **10** with **11** in the presence of acetic acid 3-acylamino-2*H*pyran-2-ones **12** are formed [25]. (Scheme3).

Cyclic 1,3-dicarbonyl compounds, such as 1,3-cyclohexanedione (**14**) and its 5,5-dimethyl derivative (**16**), afford with benzyloxycarbonylamino-3-dimethylamino-propenoate (**13**), as an example, 5,6,7,8-tetrahydro-2*H*-1-benzopyran-2-ones **15** and **17**, respectively. Phenol itself does not react, while resorcinol (**18**) and its 2-methyl derivative **20** form 2*H*-1-benzopyran-2-one derivatives **15** and **17** [26]. On the other hand, 1- (**22**) and 2-naphthol (**23**) are activated enough to give the corresponding 2*H*-naphtho[1,2-*b*]pyran-3-one **24** and 3*H*-naphtho[2,1-*b*]pyran-2-one **25** derivatives, respectively [27]. Similarly, 2,3-dihydroxynaphthalene (**26**) naphthopyranone **27** or naphthobispyranone **28.** Benzyloxacarbonyl protecting group can be easily removed by catalytic transfer hydrogenation to give free amino compounds **29**, **30**, and **31** [10]. (Scheme 4).




**Scheme 4: Synthesis of pyranones fused to carbocyclic systems**

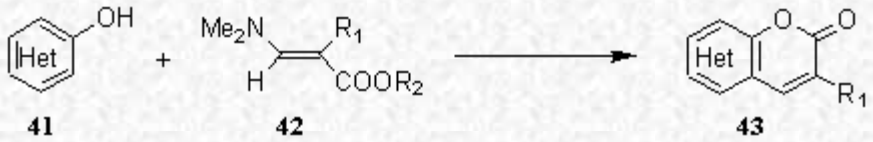
Accordingly, derivatives of the following systems have been prepared: 2*H*-pyran-2-ones **32** [8, 10, 25, 27], 5,6,7,8-tetrahydro-2*H*-benzopyran-2-one **33** [10, 15, 17, 20, 22, 27, 28], 2*H*-1-benzopyran-2-one **34** [8, 10, 11, 15, 17, 22, 28], 2*H*-naphtho[1,2-*b*]pyran-2-one **35** [8, 10, 11, 27, 28, 29], 3*H*-naphtho[2,1-*b*]pyran-3-one **36** [8, 10, 11, 15, 28, 30, 31], 5*H*-indano[1,2,-*b*]pyran-2-one **37** [30], 2*H*,6*H*-naphtho[1,2-*b*:3,4-*b?*]dipyran-2,6-dione **38** [30], 2*H*,11*H*-naphtho[2,1-*b*:3,4-*b?*]dipyran-2,11-dione **39** [30], and 3*H*,9*H*-naphtho[1,2-*b*:5,6-*b?*]dipyran-3,9-dione **40** [30]. (Scheme 5).




**Scheme 5: Pyranones and fused pyranones**

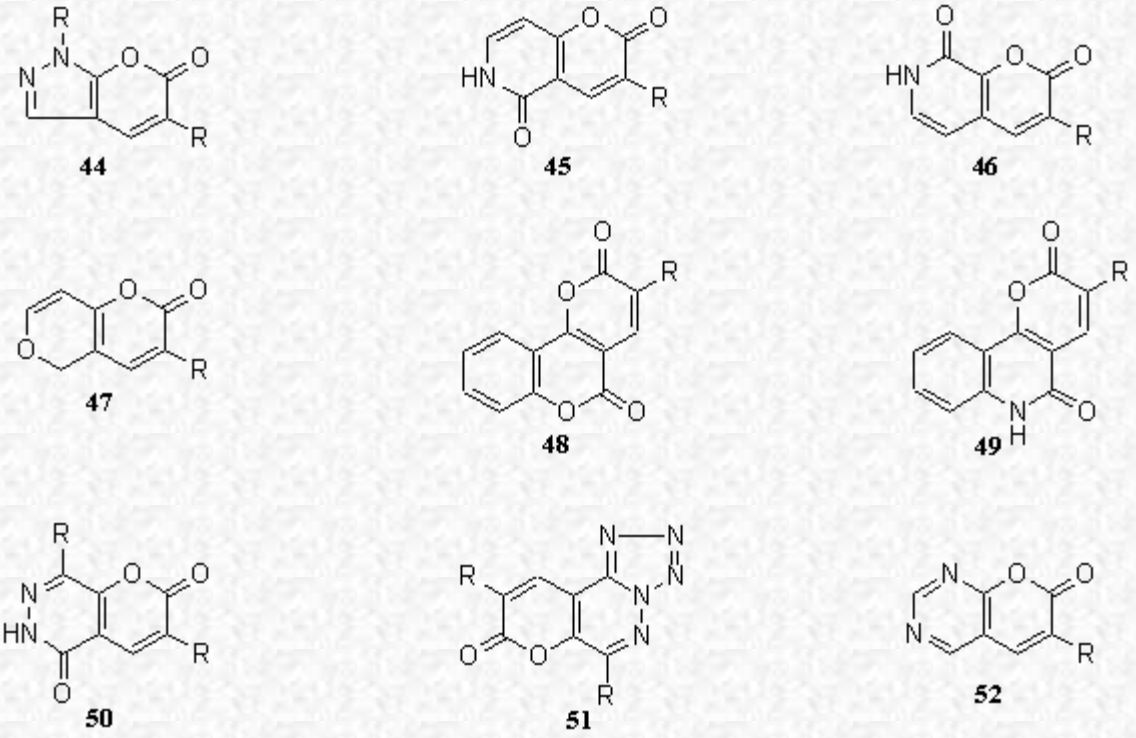
Similarly react also heterocyclic systems with a carbonyl and an adjacent metylene group as a part of the ring system **41**, or their tautomeric hydroxy forms, such as pyrazole, pyridine, pyran, benzopyran, quinoline, pyridazine, tetrazolo[1,5-*b*]pyridazine, and pyrimidine derivatives, with 2-substituted 3-dimethylaminopropenoates **42** to yield pyranones fused to a heterocyclic system **43**. (Scheme 6).

**Scheme 6: Synthesis of pyranones fused to heterocyclic system**




The following to heterocyclic systems fused pyranones have been prepared: 1*H*,6*H*-pyrano[ 2,3-*c*] pyrazole **44** [ 8,10,11,31,31,32] , 2*H*-pyrano[ 3,2-*c*] pyridine-2,5-dione **45** [ 8,10,11,15,28,31,33] , 2*H*,7*H*-pyrano[2,3-c]pyridine-2,8-dione **46**, 2*H*,5*H*-pyrano[ 4,3-*b*] pyran-2,5-dione **47** [ 10,11,14,15,28,34] , 2*H*,5*H*-pyrano[ 3,2-*c*] benzopyran-2,5-dione **48** [ 8,10,11,14,15,27,28] , 2*H*-pyrano[ 3,2-*c*] quinoline-2,5-dione **49** [ 8,11,28,33] , 2*H*-pyrano[ 2,3-*d*] pyridazine-2,5-dione **50** [ 8,28,33] , 8*H*-pyrano[ 3,2-*d*] tetrazolo[ 1,5-*b*] pyridazin-8-one **51** [ 33] , and 7*H*-pyrano[ 2,3-*d*] pyrimidin-7-one (**52**). [ 8,10,11,26,28,31] . (Scheme 7)

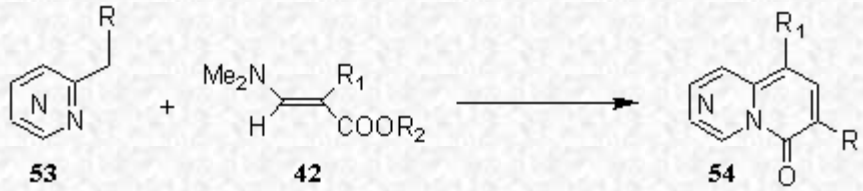
**Scheme 7: Pyranones fused to nitrogen or oxygen containing heterocycles**




**3.2 Synthesis of fused pyridinones**

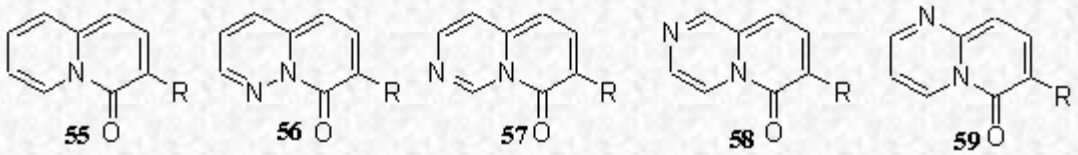
(Pyridinyl-2)acetic acid or its derivatives **53**, such as ethyl (pyridinyl-2)acetate, (pyridinyl-2)acetonitrile, and ethyl (quinolinyl-2)acetate and 2-substituted 3-dimethylaminopropenoates **42** yield by heating in acetic acid the corresponding 4*H*-quinolizin-4-ones **54** and related systems. (Scheme 8).

**Scheme 8: Synthesis of fused pyridinones**




Derivatives of the following systems have been prepared: 4*H*-quinolizin-4-one **55** [ 14,15,17,20,28,31,35,36] , 8*H*-pyrido[ 1,2-*b*] pyridazin-8-one **56** [ 36] , 8*H*-pyrido[ 1,2-*c*] pyrimidin-8-one **57** [ 36] , 6*H*-pyrido[ 1,2-*a*] pyrazin-6-one **58** [ 36] , and 6*H*-pyrido[ 1,2-*a*] pyrimidin-6-one **59** [ 36] . (Scheme 9).

**Scheme 9: Pyridinones fused to azole or azine ring**

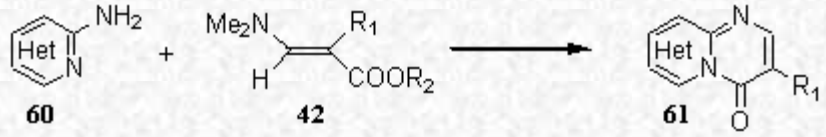


R = NH-Acyl, $NH_2$, O-Alkyl, OH, $CH_2COOMe$,..

### 3.3 Synthesis of fused pyrimidinones

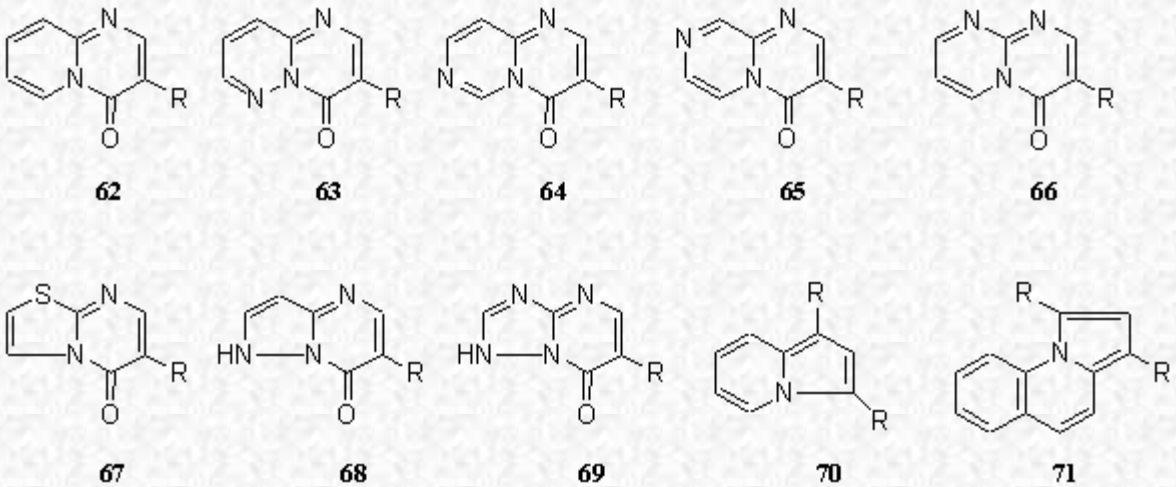
Heterocyclic a -amino compounds **60**, such as 2-aminopiridines, 3-aminopyridazines, 2- and 4-aminopyrimidines, 2-aminopyrazines, 3-aminopyrazoles, 2-aminothiazoles and others, react with 2-substituted 3-dimethylaminopropenoates **42** and related compounds to form fused pyrimidinones **61** with a bridgehead nitrogen atom. (Scheme 10)

**Scheme 10: Synthesis of fused pyrimidinones**



Accordingly, derivatives of the following systems have been prepared: 4*H*-pyrido[ 1,2-*a*] pyrimidin-4-one **62** [ 8,13,14,17, 20,22,31,37,38,39,40] , 4*H*-pyrimido[ 1,2-*b*] pyridazin-4-one **63** [ 17,37,38,40] , 4*H*-pyrimido[3,4-*a*]pyrimidin-4-one **64,** 4*H*-pyrazino[ 1,2-*a*] pyrimidin-4-one **65** [ 37,38] , 4*H*-pyrimido[3,4-*a*]pyrimidin-4-one **66,** 5*H*-thiazolo[ 3,2-*a*] pyrimidin-4-one **67** [ 8,14,17,18,20,35,37,38,41] , 7*H*-pyrazolo[ 1,5-*a*] pyrimidin-7-one **68** [ 13,31,37] , and 7*H*-1,2,4-thiazolo[ 1,5-*a*] pyrimidin-4-one **69** [ 8,37,38] , and others, such as **70** and **71**. (Scheme 11).

**Scheme 11: Pyrimidinones fused to azole or azine ring**



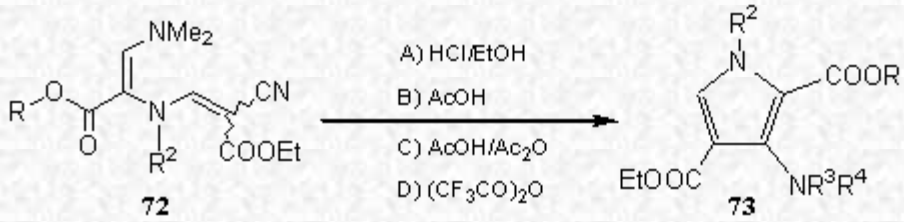
R = NH-Acyl, $NH_2$, O-Alkyl, OH, $CH_2COOMe$,..

**3.4 Synthesis of pyrroles**

3.4.1 Substituted 3-aminopyrrole-2,4-dicarboxylates

Alkyl 2-(2-alkoxycarbonyl-2-cyano-1-ethenyl)amino-3-dimethylaminopropeno-ates **72** undergo intramolecular cyclization, catalysed by acid, to give 3-aminopyrrole-2,4-dicarboxylates **73**. The structure of the final product is dependent upon the reaction conditions [ 23] . (Scheme 12)

**Scheme 12: Transformations of alkyl 2-(2-cyano-2-ethoxycarbonylethenyl)amino- 3-dimethylaminopropenoates. Synthesis of 3-amino-pyrrole-2,4-dicarboxylates**



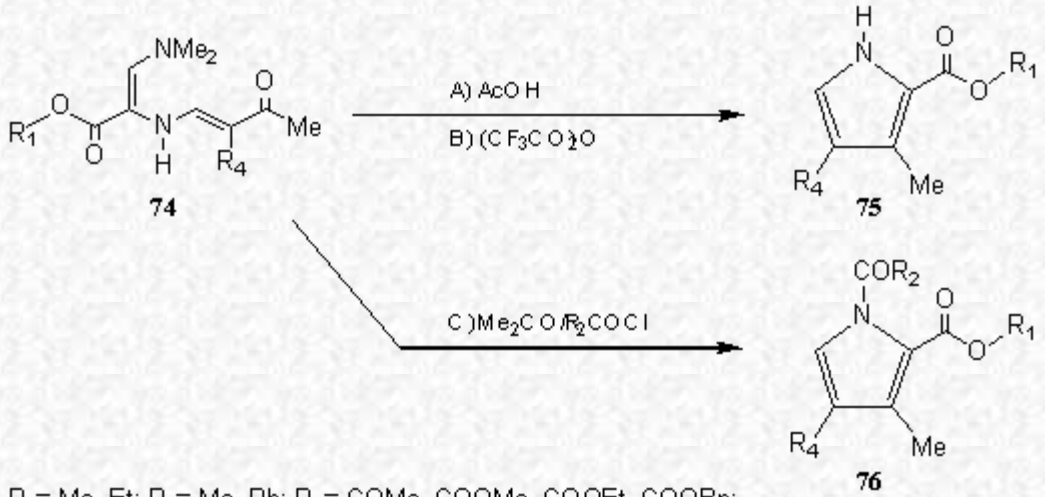

72 73

$R_1$=Me, Et; $R_2$= H, Me; $R_3$= H, COMe; $R_4$=H, COMe, $COCF_3$, CH=C(COOEt)NHCH=C(CN)COOEt
Yields 17-90%

3.4.2 Pyrrole-2-carboxylates

2-(2-Acetyl-2-benzoyl-1-ethenyl)amino-3-dimethylaminopropenoate and other alkyl 2-[ 2,2-bis(acyl)-1-ethenyl] amino-3-dimethylaminopropenoates and alkyl 2-(2-acyl-2-alkoxycarbonyl-1-ethenyl)amino-3-dimethylaminopropenoates **74** cyclize by heating in various solvents to give 3,4-disubstituted- **75** and 1-acyl-3,4-disubstituted pyrrole-2-carboxylates **76** [ 42,43] . (Scheme 13).

**Scheme 13: Transformations of alkyl 2-(2-acetyl-2-substituted-ethenyl)amino-3-dimethylaminopropenoates. Synthesis of pyrrole-2-carboxylates**



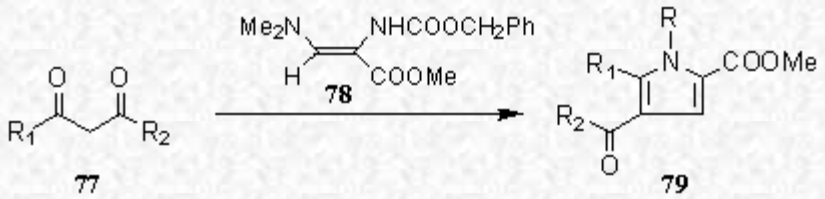

74 75 76

$R_1$= Me, Et; $R_2$= Me, Ph; $R_4$= COMe, COOMe, COOEt, COOBn;
Yields 23-60%

Methyl 2-(*N*-benzyloxycarbonyl)amino-3dimethyxlaminopropenoate **78** gives with 1,3-dicarbonyl compounds **77** 5-

substituted 4-acyl-1-benzyloxycarbonylpyrrole-2-carboxylate **79** [ 10] . (Scheme 14).

**Scheme 14: Synthesis of 4,5-disubstituted pyrrole-2-carboxylates**

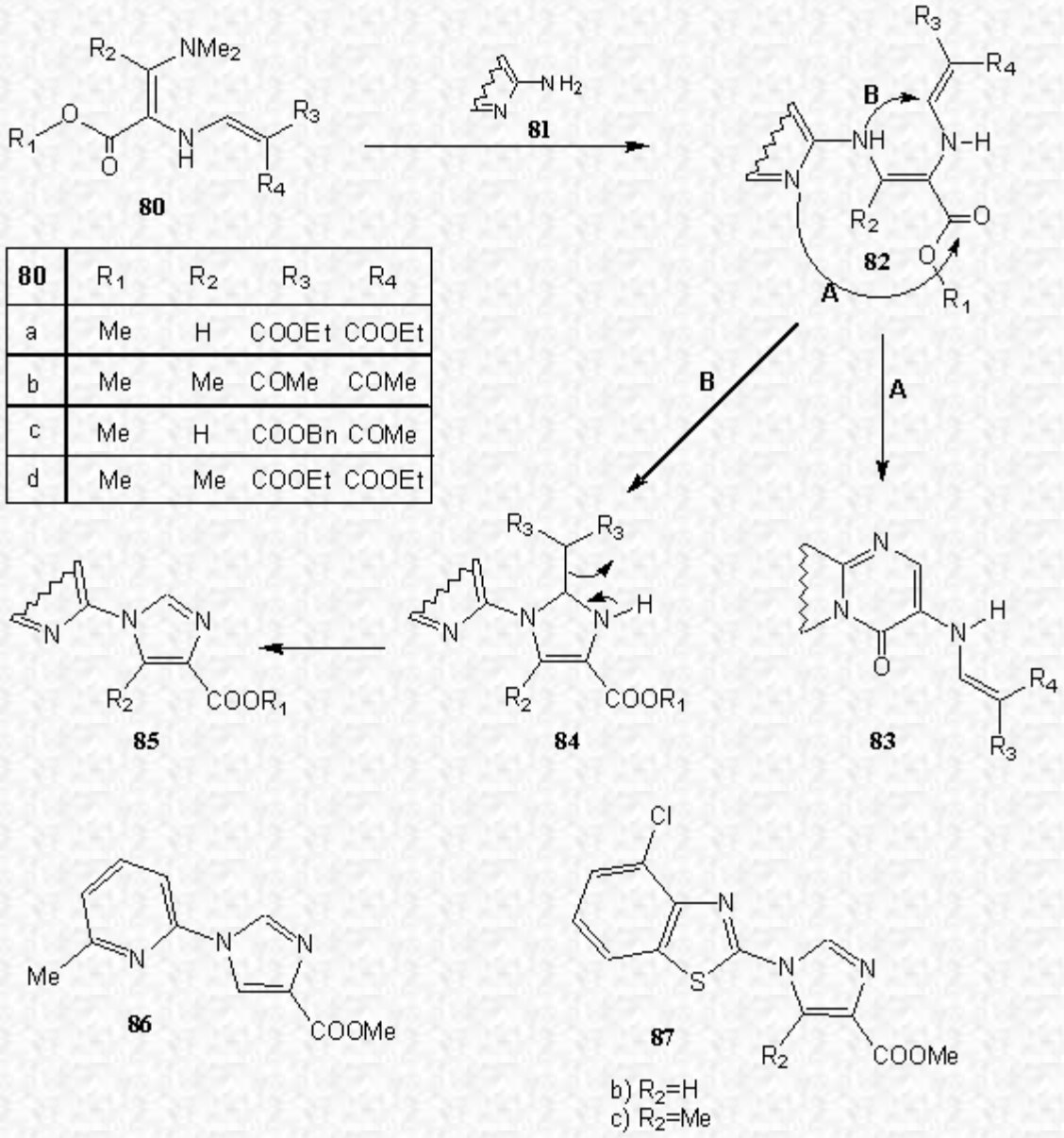



| 79 | R | $R_1$ | $R_2$ |
|---|---|---|---|
| a | H | Me | Me |
| b | H | Me | Ph |
| c | $COOCH_2Ph$ | Me | Me |

### 3.5 Synthesis of imidazole-4-carboxylates

As mentioned earlier, alkyl 2-(2,2-disubstituted 1-ethenyl)amino-3-dimethylaminopropenoates **80** and heterocyclic compounds **81**, with an amino group attached at a -position in respect to ring nitrogen atom, form intermediates **82**, which cyclize according to path A into the corresponding azolo- and azinopyrimidinones **83**. However, when these compounds are prepared from amines in which the ring nitrogen atom is sterically hindered by a substituent attached close to the ring nitrogen atom, such as in 2-amino-6-methylpyridine, 2-amino-4-chlorobenzothiazole, and its 5-methyl derivative, the reaction resulted in the formation of imidazole derivatives **85** via intermediate **84**. In this manner, methyl 1-(6-methylpyridin-2-yl)-1*H*-imidazole-4-carboxylate (**86**), methyl 1-(4-chlorobenzothiazol-2-yl)-1*H*-imidazole-4-carboxylate (**87a**), and its 5-methyl derivative **87b** are formed [ 12] . (Scheme 15).

**Scheme 15: Transformations of 2-(2,2-disubstituted-ethenyl)amino-3-dimethylamino-propenoates. Synthesis of 1-heteroaryl-imidazole-4-carboxylates.**

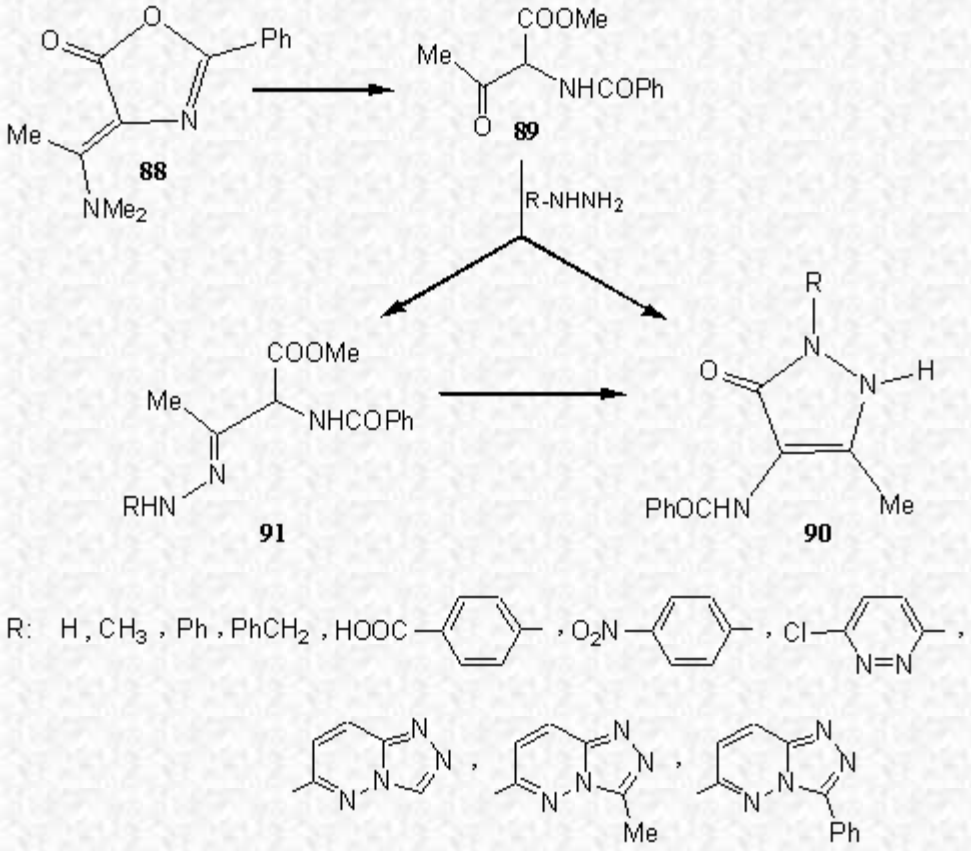



| 80 | R1 | R2 | R3 | R4 |
|---|---|---|---|---|
| a | Me | H | COOEt | COOEt |
| b | Me | Me | COMe | COMe |
| c | Me | H | COOBn | COMe |
| d | Me | Me | COOEt | COOEt |

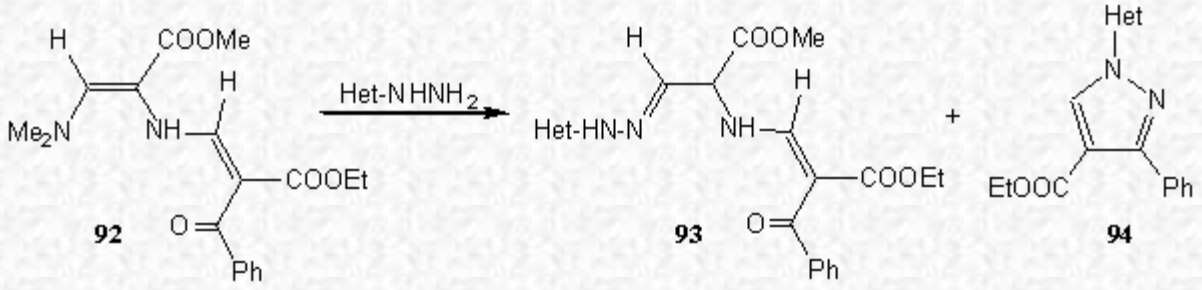
### 3.6 Synthesis of pyrazoles

4-(1-Dimethylaminoethylidene)-2-phenyl-5(4*H*)-oxazolone (**88**), prepared from hippuric acid and *N*,*N*-dimethylacetamide as an intermediate in preparation of the corresponding propenoates, gives by hydrolysis 2-benzoylamino-2-oxobutanoate (**89**). In the reaction with hydrazines the corresponding 1-substituted 4-benzoylamino-3-methylpyrazol-5(2*H*)-ones (**90**) are formed. In some cases the hydrazones **91**can be isolated as intermediates. [44]. (Scheme 16).

**Scheme 16: Transformations of methyl 2-benzoylamino-3-oxobutanoate. Synthesis of pyrazole derivatives.**



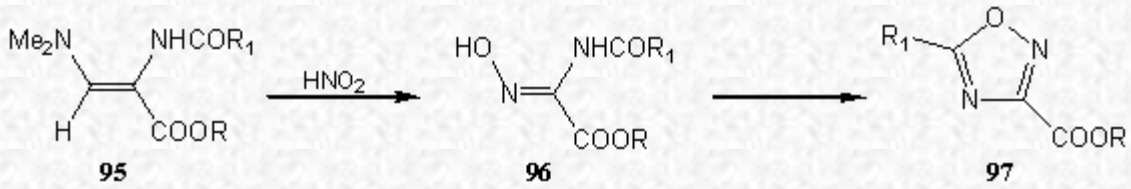

In the case of 2-(2-benzoyl-2-ethoycarbonyl-1-ethnyl)amino-3-dimethylaminopropenoate (**92**) two concurrent reactions take place, in which 2-(2-benzoyl-2-ethoycarbonyl-1-ethnyl)amino-3-heteroarylhydrazino)propenoates (**93**) and/or 4-ethoxycarbonyl-1-heteroaryl-3-phenylpyrazoles (**94**) are formed [45]. (Scheme 17).




**Scheme 17: Synthesis of pyrazole-4-carboxylates**

### 3.7 Synthesis of 1,2,4-oxadiazoles

By treatment of 2-acylamino-3-dimethylaminopropenoates (**95**) with nitrous acid at 0°C the corresponding oximes **96** are formed, which cyclize into 5-substituted 1,2,4-oxadiazol-3-carboxylates **97** [7,46]. (Scheme 18).




**95** **96** **97**

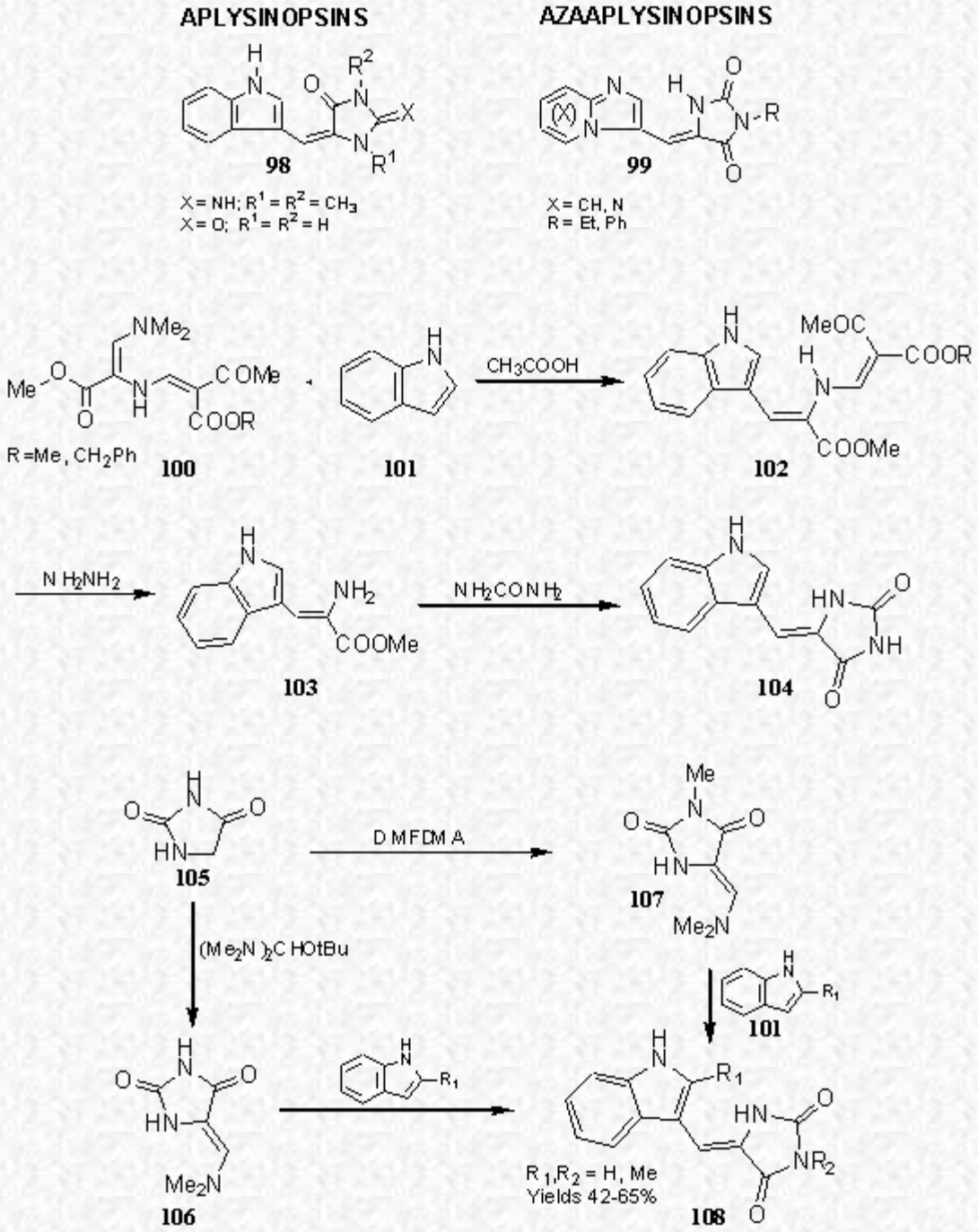
R= Me, Et
$R_1$= Me, Ph, 2-Chlorophenyl, 4-Chlorophenyl, 4-Methylphenyl, etc.

**Scheme 18: Synthesis of 1,2,4-oxadiazoles**

### 3.8. Synthesis of aplysinopsins and azaaplysinopsins

Aplysinopsins (**98**) and azaaplysinopsins (**99**) are interesting class of compounds because of their biological properties [47]. 2-(2,2-Disubstituted ethenylamino)-3-dimethylaminopropenoates can be successfully employed in the synthesis of these compounds. For example, ethyl 2-[(2-acetyl-2-methoxy(or benzyloxy)carbonylethenyl)amino]-3-dimethylaminopropenoates (**100**) react with indole (**101**) to form intermediates **102** . These, when treated with hydrazine, give intermediates **103**, from which aplysinopsin (**104**) is formed by cyclization with urea. Alternatively, the same type of compounds can be obtained also from indole (**101**) and 5-dimethylaminomethylenehydantoine (**106**), prepared from hydantoin (**105**) and *N*,*N*-dimethylformamide dimethyl acetal, in good yields [48]. (Scheme 19).

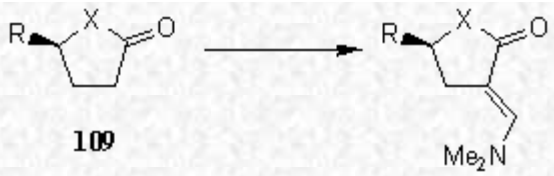
**Scheme 19: Application of 2-(2-acyl-2-alkoxycarbonyl-ethenyl)amino-3-dimethylamino-propenoates and 5-dimethylaminomethylenehydantoins in the synthesis of aplysinopsins**




**4. Synthesis and transformations of chiral 3-dimethylaminopropenoates**

Chiral analogs of 3-dimethylaminopropenoates (**110**) were prepared from tetrahydrofuran-2-ones (**109a,b**) and pyrrolidin-2-ones (**109c-e**) by treatment with *tert*-butoxybis(dimethylamino)methane, respectively [49-51]. (Scheme 20).

**Scheme 20: Synthesis of chiral 3-dimethylaminopropenoates**



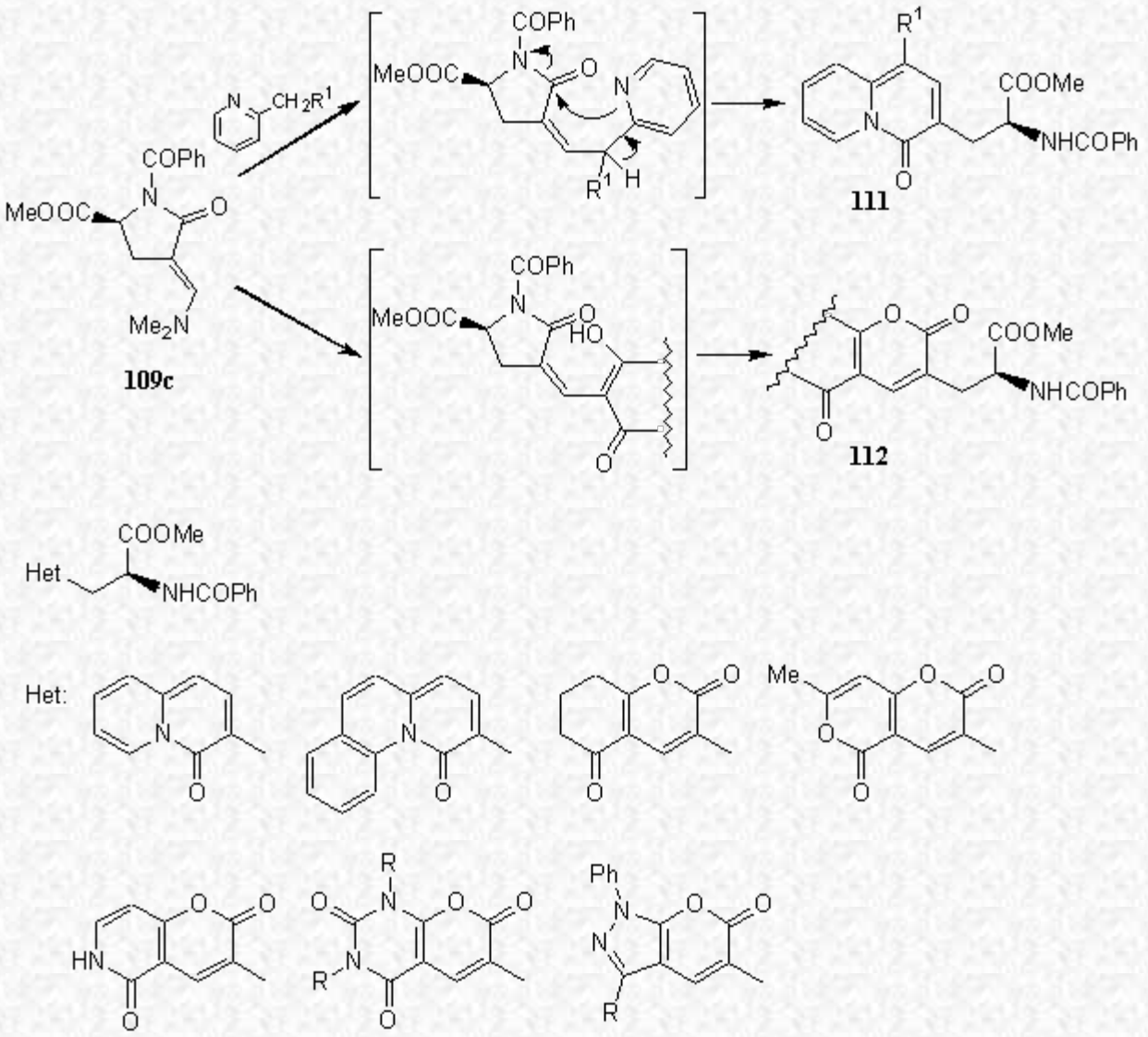

**109** **110**

| Compound | R | X | Yield |
|---|---|---|---|
| **110a** | COOMe | O | 58 |
| **110b** | $CH_2COOPh$ | O | 43 |
| **110c** | COOMe | N-COPh | 74 |
| **110d** | COOMe | N-Boc-*t* | 87 |
| **110e** | $PhCOOCH_2$ | N-COPh | 71 |

**4.1 A one-step synthesis of (*S*)-3-heteroarylalanines**

(*S*)-1-Benzoyl-3-[(*E*)-dimethylaminomethylidene]-5-methoxycarbonylpyrrolidin-2-one (**109c**) was transformed with 1,3-dinucleophiles, such as 2-(pyridinyl-2)acetates and 1,3-dicarbonyl compounds into the corresponding quinolizinyl- (**111**) and 2-oxo-2*H*-pyranyl-3 substituted alanine esters (**112**) in 50-90 % yield [52]. (Scheme 21).

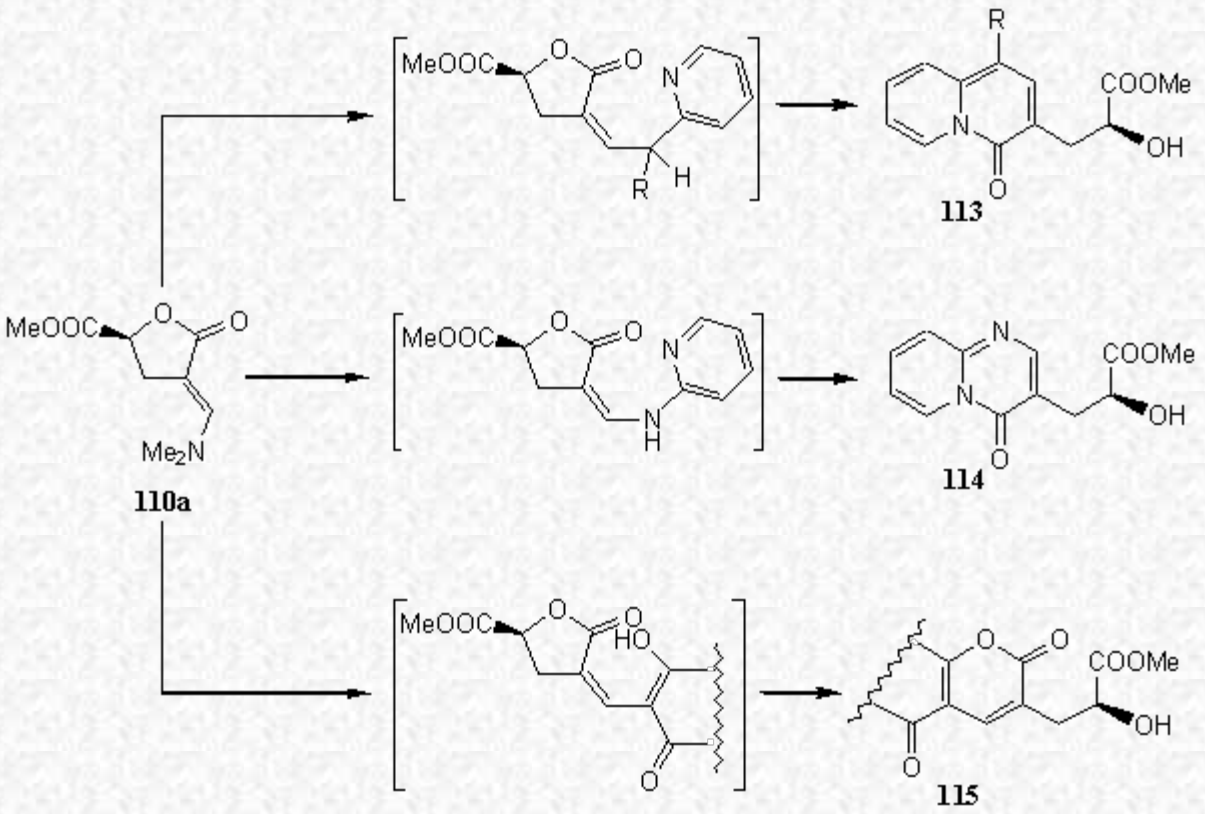
**Scheme 21: Synthesis of (*S*)-3-heteroarylalanines**

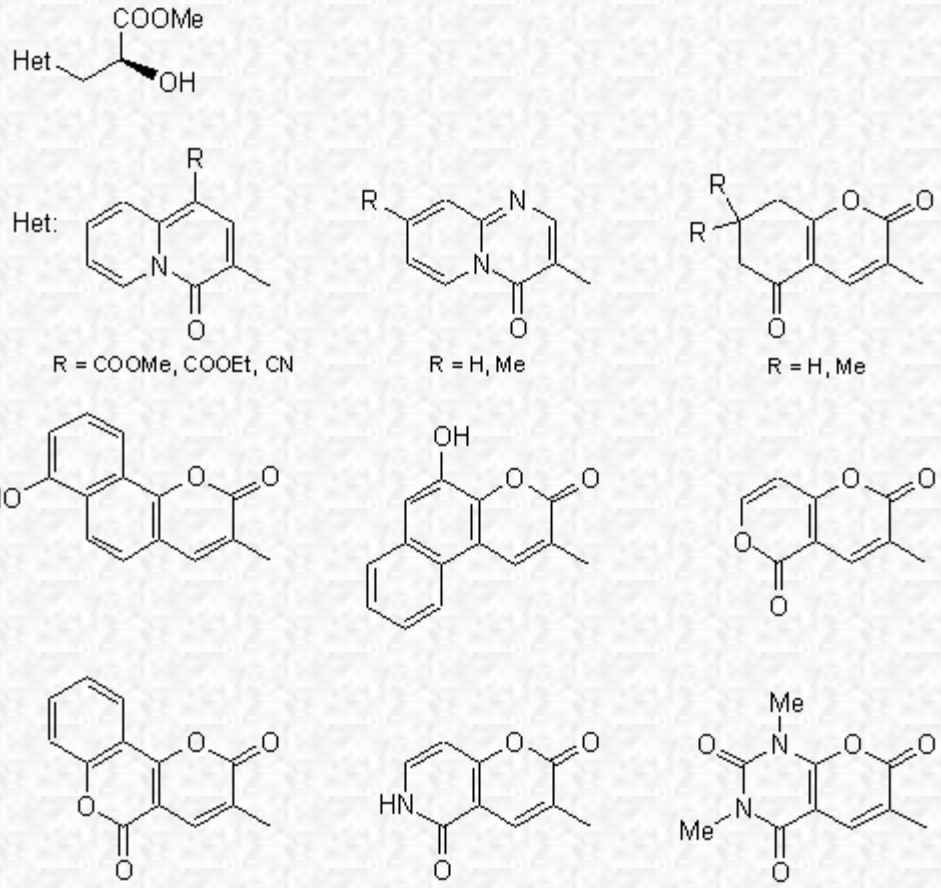



**4.2 Synthesis of 3-heteroaryl substituted lactates**

Analogously, 3-heteroaryl substituted lactic acid derivatives were prepared by ring switching methodology in a one-step transformation from (*S*)-3-[(*E*)-dimethyl- aminomethylidene]-5-methoxycarbonyltetrahydrofuran-2-one (**110a**) by treatment with 1,3-dinucleophiles. In this manner, 3-quinolizinyl-3- (**113**), 4-oxo-4*H*-pyrido[1,2-*a*]pyrmidinyl-3- (**114**), and 3-(2-oxo-2*H*-pyranyl-3)lactic acid derivatives (**115**) were obtained [53, 54]. (Scheme 22).

**Scheme 22: Synthesis of 3-heteroaryl substituted lactates**




**Acknowledgment.**

I would like to take this opportunity to express my sincere thanks and gratitude to my coworkers and students,

especially to Docent Dr. Jurij Svete, Drs. Z. Cadez, A. Copar, S. Golic Grdadolnik, A. Hvala, M. Kmetic, M. Malesic, B. Ornik, L. Pizzioli, L. Selic, G. Sorsak, S. Strah, J. Smodis, J. Tihi, M. Skof, R. Toplak, and Ph. D. students U. Bratusek, L. Jukic, S. Recnik, C. Turk, and others; all their names are included in the references. Without their enthusiastic, creative and hard work this lecture would not have been possible. My thanks are due also to Professor L. Golic and Dr. A. Golobic for X-ray structure analyses.

**References and Notes**

[1] R. M. Williams, *Synthesis of Optically Active* a *-Amino Acids*, Pergamon Press. Oxford 1989.

[2] a) R. O. Duthaler, *Tetrahedron* **50**, 1539 (1994); b) I. Wagner and H. Musso, Angew. Chem. **95**, 827 (1983); c) U. Schmidt, A. Lieberknecht, and J. Wild, *Synthesis* 1159 (1988).

[3] J. Mulzer, *Basic Principles of EPC Synthesis* in *Stereoselectie Synthesis*, Methods of Organic Chemistry (Houben-Weyl), 4th ed., Vol. 1, G. Helmchen, ed., Thieme Vellag, Stuttgart, 1996, pp.75-146.

[4] For reviews see: a) B. Stanovnik, *Methyl 2-Benzoylamino-3-dimethylamino-propenoate in the Synthesis of Heterocyclic Systems* in *Progress in Heterocyclic Chemistry*, Vol. 5, H. Suschitzky and E. F.V. Scriven, eds., Pergamon Press, Oxford, 1993, pp. 34-53; b) B.Stanovnik, *Molecules* **1**, 123 (1996)

[5] B. Stanovnik, J. Svete, M. Tisler, L. Zorz, A. Hvala, and I. Simonic, *Heterocycles* **27**, 903 (1988).

[6] Japan kokai 75 58.063; *Chem. Abstr.* **83**, P193075y (1975).

[7] M. Kmetic and B. Stanovnik, *J. Heterocyclic Chem.* **32**, 1563 (1995).

[8] L. Kralj, A. Hvala, J. Svete, L. Golic, and B. Stanovnik, *J. Heterocyclic Chem.* **34**, 247 (1997).

[9] L. Pizzioli, J, Svete, and B. Stanovnik, to be published.

[10] a) R. Toplak, J. Svete, B. Stanovnik, and S.Golic Grdadolnik *J. Heterocyclic Chem.* **36**, 225 (1999); b) S. Recnik, R. Toplak, J. Svete, L. Pizzioli, and B. Stanovnik, *J. Heterocyclic Chem.*, submitted for publication.

[11] J. Smodis and B. Stanovnik, *Tetrahedron* **54**, 9799 (1998).

[12} L. Selic and B. Stanovnik, *J. Heterocyclic Chem.* **35**, 1527 (1998).

[13] G. Sorsak, A. Sinur, L. Golic, and B. Stanovnik, *J. Heterocyclic Chem.* **32,** 921 (1995).

[14] G. Sorsak, S. Golic Grdadolnik, and B. Stanovnik, *ACH-Models in Chemistry*, **135**, 613 (1998).

[15] S. Strah, S. Golic Grdadolnik, and B. Stanovnik, *J. Heterocyclic Chem.* **34**, 263 (1997).

[16] R. Toplak, M. Zucchiati, S. Golic Grdadolnik, and B. Stanovnik, *Heterocycles* **50**, 853 (1999).

[17] L. Selic, S. Golic Grdadolnik, and B. Stanovnik, *Helv. Chim. Acta* **80**, 2418 (1997).

[18] G. Sorsak, S. Golic Grdadolnik, and B. Stanovnik, *J. Heterocyclic Chem.* **35**, 1275 (1998).

[19] M. Malesic, A. Krbavcic, A. Golobic, L. Golic, and B. Stanovnik, *J. Heterocyclic Chem.* **34**, 1757 (1997).

[20] L. Selic and B. Stanovnik, *J. Heterocyclic Chem.* **34**, 813 (1997).

[21] L. Selic and . Stanovnik, to be published.

[22] L. Selic, S. Golic Grdadolnik, and B. Stanovnik, *Heterocycles* **49**, 133 (1998).

[23] L. Selic and B. Stanovnik, *Helv. Chim. Acta* **81**, 1634 (1998)

[24] L. Selic, S. Golic Grdadolnik, and B. Stanovnik, *Heterocycles* **45**, 2349 (1997).

[25] J. Svete, Z. Cadez, B. Stanovnik, and M. Tisler, *Synthesis* 70 (1990).

[26] B. Stanovnik, J. Svete, and M. Tisler, *J. Heterocyclic Chem.* **26**, 1273 (1989).

[27] B. Ornik, Z. Cadez, B. Stanovnik, and M. Tisler, *J. Heterocyclic Chem.* **27**, 1021 (1990).

[28] R. Toplak, L.Selic, G. Sorsak, and B. Stanovnik, *Heterocycles* **45**, 555 (1997).

[29] B. Ornik, B. Stanovnik, and M.Tisler, *J.Heterocyclic Chem.* **29**, 1241 (1992).

[30] B.Ornik, B. Stanovnik, and M. Tisler, *J. Heterocyclic Chem.* **29**, 831 (1992).

[31] M. Kusar, J. Svete, and B. Stanovnik, *J. Heterocyclic Chem.* **33**, 1041 (1996).

[ 32] B. Stanovnik, J. Svete, and M. Tisler, *J. Heterocyclic Chem.* **26**, 1273 (1989).

[ 33] M. Kmetic, B. Stanovnik, M. Tisler, and T. Kappe, *J. Heterocyclic Chem.* **35**, 1331 (1993).

[ 34] B. Stanovnik, L. Golic, P. Kmecl, B. Ornik, J. Svete, and M. Tisler, *J. Heterocyclic Chem.* **28**, 1961 (1991).

[ 36] A. Copar, B. Stanovnik, and M. Tisler, *Bull. Soc. Chim. Belg.* **100**, 533 (1991).

[ 37] B. Stanovnik, H. van de Bovenkamp, J. Svete, A. Hvala, I. Simonic, and M. Tisler, *J. Heterocyclic Chem.* **27**, 359 (1990).

[ 38] R. Toplak, J. Svete,S. Golic Grdadolnik, and B. Stanovnik, *Coll. Czech Chem. Commun.* **64**, 177 (1999).

[ 39] S. Strah, A. Golobic, L. Golic, and B. Stanovnik, *J. Heterocyclic Chem.* **34**, 1511 (1997).

[ 40] L. Selic, S. Strah, R. Toplak, and B. Stanovnik, *Heterocycles* **47**, 1017 (1998).

[ 41] M. Malesic, A. Krbavcic, and B. Stanovnik, *J. Heterocyclic Chem.* **34**, 813 (1997).

[ 42] M. Malesic, A. Krbavcic, A. Golobic, L. Golic, and B. Stanovnik, *J. Heterocyclic Chem.* **34**, 1757 (1997).

[ 43] L. Selic and B. Stanovnik, *Synthesis* 479 (1999).

[ 44] U. Bratusek, A. Hvala, and B. Stanovnik, *J. Heterocyclic Chem.* **35**, 1281 (1998).

[45] S. Strah and B. Stanovnik, *J. Heterocyclic Chem.* **34**, 1629 (1997).

[46] M. Kmetic and B. Stanovnik, *J. Heterocyclic Chem.* **34**, 1705 (1997).

[47] J. M.Chezal, G. Delmas, S. Mavel, H. Elakmaoui, J. Metin, A. Diez, Y. Blache, A. Gueiffier, M. Ruboralta, J. C. Teulade, and O. Chavignon, *J. Org. Chem.* **62**, 4085 (1997).

[48] L. Selic, R. Jakse, K. Lampic, L. Golic, S. Golic Grdadolnik, and B. Stanovnik, *Helv. Chim. Acta* **83** (2000), in print.

[49] M. Skof, J. Svete, B. Stanovnik, L. Golic, S. Golic Grdadolnik, and L. Selic, *Hlv. Chim. Acta* **81**, 2332 (1998).

[50] M. Skof, J. Svete, M. Kmetic, B. Stanovnik, and S. Golic Grdadolnik, *Eur. J. Org. Chem.* **1999**, 1581.

[51] M. Skof, J. Svete, and B. Stanovnik, *Heterocycles* **53**, 339 (2000).

[52] M. Skof, J. Svete, and B. Stanovnik, *Heterocycles* **51**, 1051 (1999).

[53] M. Skof, J. Svete, and B. Stanovnik, *Heterocycles* **52**, 845 (2000).

[54] For a review about the synthesis and transformations of 3-dimethylaminopropenoates and related compounds see: B. Stanovnik and J. Svete, *Synlett* **2000**, 1077.

---



---