Unprecedented 1,3-Dipolar Cycloaddition of Azomethine Ylides Derived from Difluorocarbene and Imines to Carbonyl Compounds. − Synthesis of Oxazolidine Derivatives

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Iminiodifluoromethanides generated by the reaction of difluorocarbene with benzaldehyde and benzophenone imines undergo regioselective 1,3-dipolar cycloaddition to aldehydes to give oxazolidine derivatives.

Reactions of carbenes with heteroatomic compounds have gained considerable interest as a constituent of the general tandem ylide-formation and 1,3-dipolar-cycloaddition methodology in the stereoselective synthesis of heterocycles[1]. The attraction of this synthetic approach to heterocyclic systems, lies in the feasibility to carry out two consecutive reactions leading to ring formation as a one-pot procedure. 1,3-Dipolar cycloadditions of azomethine ylides derived from imines and dihalocarbenes are exemplified in the literature by reactions of iminiodichloromethanides, which are versatile intermediates in the synthesis of highly functionalized pyrrole[2][3][4][5], pyridine[2][5], pyrrolidine[6], indolizine[7], pyrroloisoquinoline[8] derivatives, etc. However, these reactions of iminiodichloromethanides all involve only two types of dipolarophilic agents: alkenes and alkynes. Attempts to accomplish addition of these intermediates to a C=O bond in order to obtain oxazolidine derivatives failed as carbonyl compounds much more readily react with the precursor of dichlorocarbene, trichloromethyl anion, than with the ylide[9]. Recently we have reported the generation and 1,3-dipolar cycloadditions of iminiodifluoromethanides derived from difluorocarbene and imines, to alkenes[10]. In this paper we present experimental data on the 1,3-dipolar cycloadditions of iminiodifluoromethanides to carbonyl compounds as the first successful cycloaddition of iminiodihalogenomethanides to a C=O bond, as well as the regio- and stereochemical features of this reaction.

Results and Discussion

Iminiodifluoromethanides were generated by the reaction of imines with difluorocarbene, obtained by reduction of dibromodifluoromethane with lead in the presence of tetrabutylammonium bromide[11]. In the present investigation alkylimines of benzaldehydes **1a−c** and benzophenone, **9** and **15** were employed including substrates bearing CO_2Me and $SiMe_3$ functional groups. Iminiodifluoromethanides proved to be labile, so they were generated *in situ* in the presence of an appropriate dipolarophile. A number of aldehydes and ketones were tried as dipolarophile agents.

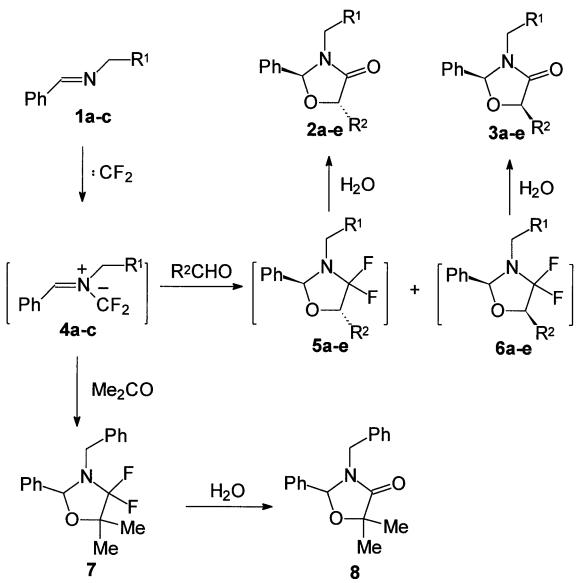
Heating a mixture of *N*-benzylidenebenzylamine (**1a**), CBr_2F_2, lead powder, tetrabutylammonium bromide, and a twofold excess of benzaldehyde in dichloromethane followed by chromatographic separation gave two diastereomeric oxazolidinones **2a** and **3a** (Scheme 1) in 25 and 14% isolated yield, respectively. Analogous reaction of ethyl benzylidene glycinate (**1b)** leads to nearly the same product ratio, but the combined yield of isomers **2b** and **3b** is appreciably lower (25%), probably because of the thermal instability of the starting imine. Reaction of ylide **4c**, generated by addition of difluorocarbene to imine **1c**, with benzaldehyde, affords a mixture of the isomeric oxazolidinones **2c** and **3c** in a ratio of ca. 2:1 and an overall yield of 37%. Increasing the reaction time above 8 h reduces the yield of the products considerably. Thus, when the reaction mixture was heated for 24 h compounds **2c** and **3c** were obtained in 5% yield each.

We also succeeded in obtaining oxazolidinones **2d** and **3d** by reaction of imine **1c** with difluorocarbene in the presence of phthalaldehyde, involving intermediate addition of ylide **4c** to only one of the carbonyl groups of the dipolarophile. Along with aromatic aldehydes, a representative of the aliphatic series, acetaldehyde, was also examined as dipolarophile in this reaction. Ylide **4a** was allowed to react with a twofold excess of acetaldehyde, giving rise to a 1:1 mixture of oxazolidinones **2e** and **3e** in an overall yield of 43%.

The structures of the synthesized oxazolidinones **2** and **3** were assigned on the basis of the spectral data. The ^1H

  1434−193X/98/0101−0133 $ 17.50+.50/0

Scheme 1



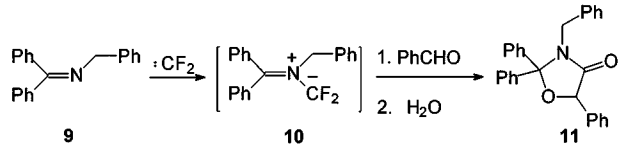
1, **4**: R^1 = Ph (**a**), CO_2Me (**b**), $SiMe_3$ (**c**);
2 - **6**: R^1 = R^2 = Ph (**a**); R^1 = CO_2Me, R^2 = Ph (**b**); R^1 = $SiMe_3$, R^2 = Ph (**c**); R^1 = Ph, R^2 = 2-C_6H_4CHO (**d**); R^1 = Ph, R^2 = Me (**e**).

NMR spectra were most informative in determining the configuration of the products **2**, **3**. As a consequence of the deshielding effect of the phenyl groups at C-2 and C-5 the signals of the protons 2-H and 5-H in the *trans*-isomer are shifted downfield by 0.2−0.3 ppm with respect to the corresponding signals of the *cis*-isomers[12]. On this basis compounds **2** were assigned the *trans*-configuration and compounds **3** the *cis*-configuration.

Iminiodifluoromethanide, generated by reaction of difluorocarbene and imine **1a**, adds to acetone to give, after chromatographic workup, the oxazolidinone **8** in only 3% isolated yield. The analogous reaction with benzophenone does not provide the corresponding product, but gives only polymeric material.

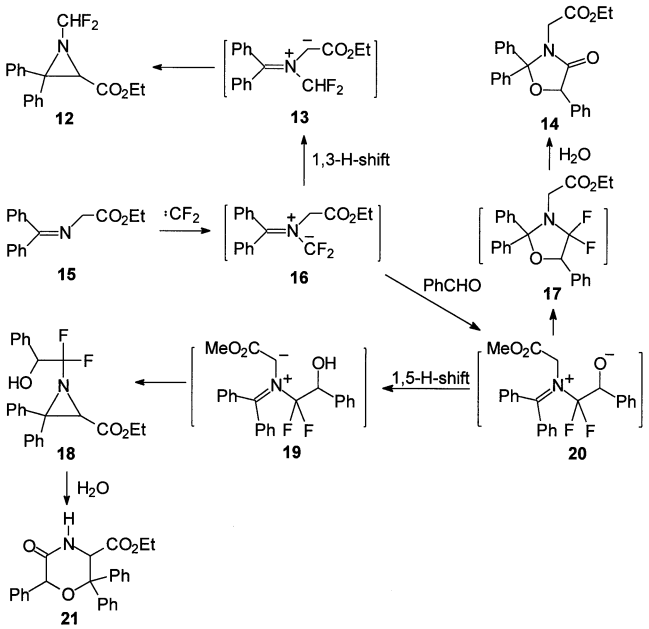
According to the published data[14], ylides derived from dichlorocarbene and benzophenone imines rapidly cyclize to the corresponding aziridines and all attempts to trap them by 1,3-dipolar cycloaddition to activated alkenes failed. Therefore it was quite unexpected to discover the tendency of the analogous difluoromethylides **10**, **16** to react in a cycloaddition. At the same time, no products resulting from a 1,3-cyclization were detected. Ylide **10** generated from difluorocarbene and *N*-benzhydrylidenebenzylamine (**9**) readily adds to the C=O bond of benzaldehyde to give, after hydrolysis on silica gel, the oxazolidinone **11** in 75% yield (Scheme 2).

Scheme 2



Glycine derivative **15** reacts under similar conditions in a more complex manner, yielding along with the cycloaddition product oxazolidinone **14** (25%), difluoromethylaziridine **12** (11%) and aziridine **18** (5%) as well, which could be easily separated by column chromatography (Scheme 3). The latter is not very stable, and quantitatively transforms into the morpholine derivative **21** in chloroform solution in a few hours. Aziridine **12** is a known compound isolated as the sole product of the reaction of imine **15** with difluorocarbene in the absence of a dipolarophile[15].

Scheme 3



Thus, iminiodifluoromethanides **4a−c, 10**, and **16**, generated by addition of difluorocarbene to imines of benzaldehyde **1a−c** and benzophenone **9** and **15**, respectively, are able to add to the C=O bond of aldehydes to give oxazolidines of the type **5**, **6**, and **17**. Earlier we detected by GC-MS analogous primary cycloaddition products in the reactions of ylide **4a** with dimethylmaleate and fumarate[10]. All these intermediates proved to be unstable during chromatographic workup on silica gel, undergoing rapid hydrolysis to the corresponding oxazolidinones of type **2**, **3**, **11**, and **14**. In all cases the cycloaddition proceeds with high regioselectivity, providing only one regioisomer. Ylides **4a−c** derived from benzaldehyde imines add to the C=O bond of aldehydes to give both stereoisomers, with preferential formation of the *trans*-adduct in the case of aromatic aldehydes as dipolarophile and without any stereocontrol in the case of acetaldehyde. In contrast to azomethine ylides derived from other dihalocarbenes, iminiodifluoromethanides generated from benzophenone imines and difluorocarbene show unusual ability to react in a 1,3-dipolar cycloaddition. According to MNDO calculations, in the ylide $Ph_2C=N^+(CH_3)-C^-F_2$ the phenyl rings are twisted by 85−90° with respect to the $C=N^+-C^-$ plane, and consequently, should strongly shield the CPh_2 carbon, and thus inhibit concerted cycloaddition. Nevertheless, the reaction of im-

ines **9** and **15** with benzaldehyde under difluorocarbene-generating conditions gives rise to cycloaddition products **11** and **14**, respectively.

The anomalous behavior of C,C-diphenyl-substituted difluoroylides is best explained by the possibility of a nonconcerted addition to the C=O bond, involving intermediate formation of zwitterion **20** and its 1,5-cyclization. Such a mechanism of the reaction may be caused by steric hindrance to concerted cycloaddition to the C=O bond of benzaldehyde and by a high barrier to 1,3-cyclization into gem-difluoroaziridine[14]. Evidence in favor of this mechanism is provided by the presence of aziridine **18** among the reaction products of imine **15**. Formation of **18** most probably occurs via 1,5-H-shift in zwitterion **20** and subsequent cyclization of the resulting ylide **19**. When ylide **16** has a sufficiently acidic proton in the α-position to the nitrogen, a reaction concurrent with the addition at the carbonyl group of the dipolarophile occurs that involves a formal 1,3-H-shift[5][15] to give ylide **13** followed by 1,3-cyclization to aziridine **12**.

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Experimental Section

General: IR: Carl−Zeiss UR 20. − ^1H NMR: Bruker WM 400 (400 MHz), Bruker AC 250 (250 MHz); internal standard TMS (δ = 0) . − ^{13}C NMR: Bruker WM 400 (100.62 MHz), Bruker AC 250 (62.90 MHz); internal standard $CHCl_3$ (δ = 77.0) or TMS (δ = 0). − ^{19}F NMR: Varian Gemini 200 BB (188.143 MHz); external standard $CFCl_3$. All NMR spectra were measured in $CDCl_3$ unless otherwise stated. − MS: 311 A Varian MAT, 70 eV. − Elemental analyses: Hewlett−Packard 185 B and Carlo Erba EA 1108 CHN-analysers.

All reactions were carried out in dried solvents under nitrogen or argon, using rigorously dried glassware. Column chromatography: silica gel 60, 40−63 μm (Merck) and silica gel LS 5/40 (Chemapol); eluent petroleum ether/diethyl ether.

Synthesis of Starting Imines: **1b** − ref.[16], **1c** − ref.[17], **9** − ref.[18] and **15** − ref.[19].

General Procedure. A flask was charged in succession with lead powder (10 mmol), tetrabutylammonium bromide (20 mmol), dichloromethane (25 ml), imine (5 mmol), dibromodifluoromethane (20 mmol) and a carbonyl compound [benzaldehyde (10 mmol), acetaldehyde (10 mmol), phthalaldehyde (6 mmol), acetone (40 mmol) or benzophenone (20 mmol)]. The flask was then tightly stoppered. The mixture was stirred with a magnetic stirrer at 50 C until all the lead was consumed (8 to 30 h). The solvent was removed under reduced pressure and the residue was separated by silica gel chromatography.

(2R,5R)- (**2a**) *and (2R,5S)-(±)-3-Benzyl-2,5-diphenyloxazolidin-4-ones* (**3a**) were prepared from imine **1a** and benzaldehyde according to the general procedure.

2a: Colorless needles, m.p. 95−97 °C (pentane/ether), 25% yield. − IR (CCl_4): $\tilde{\nu}$ = 1730 cm^{-1} (C=O). − ^1H NMR: δ = 3.57 (d, *J* = 14.8 Hz, 1 H, CH_2), 5.06 (d, *J* = 14.8 Hz, 1 H, CH_2), 5.60 (d, *J* = 2.0 Hz, 1 H, 5-H), 5.95 (d, *J* = 2.0 Hz, 1 H, 2-H), 7.0−7.5 (m, 15 H, aromatic H). − ^{13}C NMR: δ = 43.90 (CH_2), 79.18 (C-5), 90.84 (C-2), 126.27, 127.43, 127.91, 128.17, 128.53, 128.70, 128.75, 129.00, 130.24, 135.16, 136.57, 136.74 (aromatic C), 169.97 (C-4). $C_{22}H_{19}NO_2$ (329.4): calcd. C 80.22, H 5.81, N 4.25; found C 80.01, H 5.84, N 4.24.

3a: Colorless prisms, m.p. 97−99 °C (ether) (ref.[14] 95−97°C), 14% yield. − IR (CCl_4): $\tilde{\nu}$ = 1730 cm^{-1} (C=O). − ^1H NMR: δ = 3.63 (d, *J* = 14.8 Hz, 1 H, CH_2), 4.98 (d, *J* = 14.8 Hz, 1 H, CH_2), 5.39 (d, *J* = 2.0 Hz, 1 H, 5-H), 5.84 (d, *J* = 2.0 Hz, 1 H, 2-H), 7.0−7.6 (m, 15 H, aromatic H). − ^{13}C NMR: δ = 44.32 (CH_2), 79.39 (C-5), 90.15 (C-2), 126.61, 127.92, 128.18, 128.48, 128.50, 128.54, 128.72, 128.90, 130.39, 135.30, 135.91, 135.97 (aromatic C), 170.22 (C-4). − MS (70 eV); *m/z* (%): 329 (0.02) [M^+], 238 (22) [M^+ − $PhCH_2$], 223 (23) [M^+ − PhCHO], 91 (65) [$PhCH_2^+$]. $-C_{22}H_{19}NO_2$ (329.4): calcd. C 80.22, H 5.81, N 4.25; found C 80.20, H 5.84, N 4.27.

Methyl (2′R,5′R)- (**2b**) *and (2′R,5′S)-(±)-(4′-Oxo-2′,5′-diphenyloxazolidin-3′-yl)acetates* (**3b**) were prepared from imine **1b** and benzaldehyde according to the general procedure.

2b: Pale yellow oil, 15% yield. − IR (CCl_4): $\tilde{\nu}$ = 1765 cm^{-1} (OC=O), 1735 (NC=O). − ^1H NMR: δ = 3.32 (d, *J* = 17.8 Hz, 1 H, CH_2), 3.69 (s, 3 H, CH_3), 4.51 (d, *J* = 17.8 Hz, 1 H, CH_2), 5.57 (d, *J* = 2.0 Hz, 1 H, 5-H), 6.38 (d, *J* = 2.0 Hz, 1 H, 2-H), 7.2−7.6 (m, 10 H, aromatic H). − ^{13}C NMR: δ = 41.23 (CH_2), 52.41 (CH_3), 79.38 (C-5), 91.21 (C-2), 126.92, 127.52, 128.76, 128.79, 129.12, 130.54, 135.90, 136.18 (aromatic C), 168.21 and 170.71 (C=O). − MS (70 eV); *m/z* (%): 311 (2.5) [M^+], 238 (18) [M^+ − $CH_3CO_2CH_2$]. − $C_{18}H_{17}NO_4$ (311.3): calcd. C 69.44, H 5.51, N 4.50; found C 69.21, H 5.54, N 4.37.

3b: Pale yellow oil, 10% yield. − IR (CCl_4): $\tilde{\nu}$ = 1765 cm^{-1} (OC=O), 1740 (NC=O). − ^1H NMR: δ = 3.33 (d, *J* = 17.8 Hz, 1 H, CH_2), 3.72 (s, 3 H, CH_3), 4.44 (d, *J* = 17.8 Hz, 1 H, CH_2), 5.45 (d, *J* = 2.0 Hz, 1 H, 5-H), 6.27 (d, *J* = 2.0 Hz, 1 H, 2-H), 7.2−7.6 (m, 10 H, aromatic H). − ^{13}C NMR: δ = 41.57 (CH_2), 52.43 (CH_3), 79.25 (C-5), 90.28 (C-2), 126.86, 128.04, 128.26, 128.59, 128.67, 129.10, 135.39, 135.55 (aromatic C), 168.33 and 171.13 (C=O). − MS (70 eV); *m/z* (%): 311 (4) [M^+], 238 (18) [M^+ − $CH_3CO_2CH_2$]. − $C_{18}H_{17}NO_4$ (311.3): calcd. C 69.44, H 5.51, N 4.50; found C 69.39, H 5.58, N 4.42.

(2R,5R)- (**2c**) *and (2R,5S)-(±)-2,5-Diphenyl-3-(trimethylsilylmethyl)oxazolidin-4-ones* (**3c**) were prepared from imine **1c** and benzaldehyde according to the general procedure.

2c: Pale yellow oil, 25% yield. − IR (CCl_4): $\tilde{\nu}$ = 1720 cm^{-1} (C=O). − ^1H NMR: δ = 0.00 (s, 9 H, CH_3), 2.13 (d, *J* = 15.3 Hz, 1 H, CH_2), 3.07 (d, *J* = 15.3 Hz, 1 H, CH_2), 5.50 (d, *J* = 2.3 Hz, 1 H, 5-H), 6.11 (d, *J* = 2.3 Hz, 1 H, 2-H), 7.0−7.6 (m, 10 H, aromatic H). − ^{13}C NMR: δ = −1.52 (CH_3), 31.66 (CH_2), 78.89 (C-5), 93.02 (C-2), 126.20, 127.36, 128.51, 128.64, 129.07, 133.51, 136.94, 136.97 (aromatic C), 169.25 (C-4). − MS (70 eV); *m/z* (%): 325 (0.02) [M^+], 310 (3) [M^+ − CH_3], 219 (42) [M^+ − PhCHO], 73 (60) [$SiMe_3^+$]. − $C_{19}H_{23}NO_2Si$ (325.5): calcd. C 70.11, H 7.12, N 4.30; found C 69.88, H 7.05, N 4.34.

3c: Pale yellow oil, 12% yield. − IR (CCl_4): $\tilde{\nu}$ = 1720 cm^{-1} (C=O). − ^1H NMR: δ = 0.04 (s, 9 H, CH_3), 2.23 (d, *J* = 15.2 Hz, 1 H, CH_2), 2.88 (d, *J* = 15.2 Hz, 1 H, CH_2), 5.35 (d, *J* = 1.5 Hz, 1 H, 5-H), 5.97 (d, *J* = 1.5 Hz, 1 H, 2-H), 7.1−7.5 (m, 10 H, aromatic H). − ^{13}C NMR: δ = −1.26 (CH_3), 32.10 (CH_2), 79.31 (C-5), 92.39 (C-2), 126.70, 128.20, 128.40, 128.48, 128.97, 130.36, 136.25, 136.43 (aromatic C), 169.50 (C-4). − MS (70 eV); *m/z* (%): 325 (0.3) [M^+], 310 (1.5) [M^+ − CH_3], 219 (69) [M^+ − PhCHO], 73 (85) [$SiMe_3^+$]. − $C_{19}H_{23}NO_2Si$ (325.5): calcd. C 70.11, H 7.12, N 4.30; found C 69.85, H 7.11, N 4.34.

(2′R,5′R)- (**2d**) *and (2′R,5′S)-(±)-2-[4′-Oxo-2′-phenyl-3′-(trimethylsilylmethyl)oxazolidin-5′-yl]benzaldehydes* (**3d**) were prepared from imine **1c** and phthalaldehyde according to the general procedure. **2d**: Pale yellow oil, 3% yield. − IR (CCl_4): $\tilde{\nu}$ = 1720 cm^{-1} (CC=O, NC=O). − ^1H NMR: δ = 0.00 (s, 9 H, CH_3), 2.17 (d, *J* = 15.3 Hz, 1 H, CH_2), 3.06 (d, *J* = 15.3 Hz, 1 H, CH_2), 6.14 (d, *J* = 2.6 Hz, 1 H, 5-H), 6.51 (d, *J* = 2.6 Hz, 1 H, 2-H), 7.2−8.0 (m, 19 H, aromatic H), 10.35 (s, 1 H, OC−H). − ^{13}C NMR: δ = −1.54 (CH_3), 31.81 (CH_2), 75.17 (C-5), 93.14 (C-2), 126.31, 127.18, 128.71, 129.12, 130.33, 131.59, 133.73 134.17, 136.76, 138.62 (aromatic C), 168.06 (C-4), 191.30 (HC=O). − MS (70 eV); *m/z* (%): 353 (7) [M^+], 338 (4) [$M^+ - CH_3$], 247 (22) [$M^+ - C_6H_5(CHO)$], 77 (17) [Ph^+], 73 (100) [$SiMe_3^+$]. − $C_{20}H_{23}NO_3Si$ (353.5): calcd. C 67.96, H 6.56, N 3.96; found C 67.72, H 6.59, N 3.91.

3d: Pale yellow oil, 10% yield. − IR (CCl_4): $\tilde{\nu}$ = 1720 cm^{-1} (CC=O, NC=O). − ^1H NMR: δ = 0.05 (s, 9 H, CH_3), 2.23 (d, *J* = 15.3 Hz, 1 H, CH_2), 2.92 (d, *J* = 15.3 Hz, 1 H, CH_2), 6.04 (d, *J* = 2.0 Hz, 1 H, 5-H), 6.44 (d, *J* = 2.0 Hz, 1 H, 2-H), 7.0−8.2 (m, 19 H, aromatic H), 10.32 (s, 1 H, OC−H). − ^{13}C NMR: δ = −1.30 (CH_3), 32.24 (CH_2), 75.24 (C-5), 92.29 (C-2), 126.71, 128.11, 128.63, 129.01, 130.47, 131.75, 133.75, 134.21, 136.05, 137.43 (aromatic C), 168.51 (C-4), 191.51 (HC=O). − MS (70 eV); *m/z* (%): 353 (5) [M^+], 247 (22) [$M^+ - C_6H_5(CHO)$], 77 (32) [Ph^+], 73 (100) [$SiMe_3^+$]. − $C_{20}H_{23}NO_3Si$ (353.5): calcd. C 67.96, H 6.56, N 3.96; found C 67.75, H 6.45, N 3.89.

(2R,5R)- (**2e**) *and (2R,5S)-(±)-3-Benzyl-5-methyl-2-phenyloxazolidin-4-ones* (**3e**) were prepared from imine **1a** and acetaldehyde according to the general procedure. − Pale yellow oil, 43% combined yield (mixture 1:1). − IR (CCl_4): $\tilde{\nu}$ = 1730 cm^{-1} (C=O). − MS (70 eV); *m/z* (%): 267 (0.5) [M^+], 190 (10) [$M^+ - Ph$], 176 (81) [$M^+ - PhCH_2$], 91 (100) [$PhCH_2^+$]. **2e**: ^1H NMR: δ = 1.49 (d, *J* = 7.1 Hz, 3 H, CH_3), 3.52 (d, *J* = 15.0 Hz, 1 H, CH_2), 4.72 (qd, *J* = 7.1, 2.5 Hz, 1 H, 5-H), 5.04 (d, *J* = 15.0 Hz, 1 H, CH_2), 5.73 (d, *J* = 2.5 Hz, 1 H, 2-H), 7.0−7.5 (m, 10 H, aromatic H). − ^{13}C NMR: δ = 17.62 (CH_3), 43.63 (CH_2), 74.16 (C-5), 89.76 (C-2), 126.2−136.7 (aromatic C), 172.34 (C-4). − **3e**: ^1H NMR: δ = 1.59 (d, *J* = 6.6 Hz, 3 H, CH_3), 3.54 (d, *J* = 14.8 Hz, 1 H, CH_2), 4.50 (qd, *J* = 6.6, 2.0 Hz, 1 H, 5-H), 4.94 (d, *J* = 14.8 Hz, 1 H, CH_2), 5.68 (d, *J* = 2.0 Hz, 1 H, 2-H), 7.0−7.5 (m, 10 H, aromatic H). − ^{13}C NMR: δ = 17.99 (CH_3), 43.87 (CH_2), 74.46 (C-5), 89.94 (C-2), 126.2−136.7 (aromatic C), 172.34 (C-4). − $C_{17}H_{17}NO_2$ (267.3): calcd. C 76.38, H 6.41, N 5.24; found C 76.53, H 6.39, N 5.26.

3-Benzyl-5,5-dimethyl-2-phenyloxazolidin-4-one (**8**) was prepared from imine **1a** and acetone according to the general procedure. − Colorless needles, m.p. 81−83 °C (hexane), 2.5% yield. − IR (CCl_4): $\tilde{\nu}$ = 1725 cm^{-1} (C=O). − ^1H NMR: δ = 1.43 (s, 3 H, CH_3), 1.59 (s, 3 H, CH_3), 3.49 (d, *J* = 14.8 Hz, 1 H, CH_2), 4.97 (d, *J* = 14.8 Hz, 1 H, CH_2), 5.62 (s, 1 H, 2-H), 7.0−7.5 (m, 10 H, aromatic H). − ^{13}C NMR: δ = 23.18 (CH_3), 25.12 (CH_3), 43.76 (CH_2), 79.85 (C-5), 87.91 (C-2), 127.78, 128.16, 128.30, 128.72, 128.84, 130.13, 135.56, 136.25 (aromatic C), 174.41 (C-4). − MS (70 eV); *m/z* (%): 281 (1) [M^+], 204 (10) [$M^+ - Ph$], 190 (83) [$M^+ - PhCH_2$], 91 (100) [$PhCH_2^+$]. − $C_{18}H_{19}NO_2$ (281.4): calcd. C 76.84, H 6.81, N 4.98; found C 76.71, H 6.85, N 4.96.

3-Benzyl-2,2,5-triphenyloxazolidin-4-one (**11**) was prepared from imine **9** and benzaldehyde according to the general procedure. − Colorless prisms, m.p. 131−133°C (ether/CH_2Cl_2), 75% yield. − IR (CCl_4): $\tilde{\nu}$ = 1730 cm^{-1} (C=O). − ^1H NMR: δ = 4.22 (d, *J* = 15.0 Hz, 1 H, CH_2), 4.98 (d, *J* = 15.0 Hz, 1 H, CH_2), 5.19 (s, 1 H, 5-H), 6.7−7.6 (m, 20 H, aromatic H). − ^{13}C NMR: δ = 45.92 (CH_2), 77.40 (C-5), 98.01 (C-2), 126.87, 127.29, 127.72, 127.91, 127.92, 128.03, 128.35, 128.57, 128.68, 129.05, 129.28, 135.62, 136.43, 139.15, 139.60 (aromatic C), 171.28 (C-4). − MS (70 eV); *m/z* (%): 405 (1) [M^+], 328 (24) [$M^+ - Ph$], 91 (100) [$PHCH_2^+$], 77 (55) [Ph^+]. − $C_{28}H_{23}NO_2$ (405.5): calcd. C 82.94, H 5.72, N 3.45; found C 82.92, H 5.75, N 3.28.

Ethyl (4-Oxo-2,2,5-triphenyloxazolidin-3-yl)acetate (**14**), *Ethyl 1-(Difluoromethyl)-3,3-diphenylaziridine-2-carboxylate* (**12**) *and Ethyl 1-[(1,1-Difluoro-2-hydroxy-2-phenyl)ethyl]-3,3-diphenylaziridine-2-carboxylate* (**18**) were prepared from imine **15** and benzaldehyde according to the general procedure. − **14**: Colorless prisms, m.p. 78−80 °C (pentane/ether), 25% yield. − IR (CCl_4): $\tilde{\nu}$ = 1770 cm^{-1} (OC=O), 1745 (NC=O). − ^1H NMR: δ = 1.05 (t, *J* = 7.1 Hz, 3 H, CH_3), 3.82 (m, 2 H, OCH_2), 3.89 (d, *J* = 17.3 Hz, 1 H, NCH_2), 4.47 (d, *J* = 17.3 Hz, 1 H, NCH_2), 5.28 (s, 1 H, 5-H), 7.2−7.6 (m, 15 H, aromatic H). − ^{13}C NMR: δ = 13.84 (CH_3), 43.14 (NCH_2), 61.35 (OCH_2), 78.27 (C-5), 97.67 (C-2), 127.18, 128.16, 128.18, 128.39, 128.53, 128.67, 128.90, 129.16, 129.39, 135.63, 135.89, 140.01 (aromatic C), 166. 72 (C=O), 171.01 (C=O). − MS (70 eV); *m/z* (%): 401 (0.3) [M^+], 356 (0.3) [M^+ − EtO], 324 (100) [M^+ − Ph]. − $C_{25}H_{23}NO_4$ (401.5): calcd. C 74.80, H 5.77, N 3.49; found C 74.76, H 5.81, N 3.52. − **12**: M.p. 96−98 °C (ether/pentane) (ref.[15] 94.5−96 °C), 11% yield. − ^{13}C NMR: δ = 13.72 (CH_3), 43.79 (d, J_{C-F} = 3 Hz, C-2), 55.94 (d, J_{C-F} = 5 Hz, C-3), 61.33 (CH_2), 116.27 (dd, J_{C-F} = 246, 243 Hz, CF_2), 127.79, 127.96, 128.06, 128.92, 128.97, 129.73, 135.46, 137.61 (aromatic C), 166.16 (C=O). − **18**: Colorless prisms, m.p. 100 °C dec. (ether/pentane), 5% yield. − IR (CCl_4): $\tilde{\nu}$ = 3500 cm^{-1} (OH), 1750 (C=O). − ^1H NMR (C_6D_6): δ = 0.60 (t, *J* = 7.1 Hz, 3 H, CH_3), 3.66 (m, 2 H, OCH_2), 3.92 (d, *J* = 5.1 Hz, 1 H, OH), 3.97 (d, *J* = 2.0 Hz, 1 H, 2-H), 5.12 (ddd, J_{HF} = 5.6, 14.3 Hz, J_{HH} = 5.1 Hz, 1 H, HOC−H), 6.9−7.6 (m, 15 H, aromatic H). − ^{13}C NMR ([D_6]acetone): δ = 14.20 (CH_3), 45.89 (C-2), 55.81 (C-3), 61.33 (CH_2), 76.05 (t, J_{CF} = 31.7 Hz, C−OH), 124.17 (dd, J_{CF} = 277, 248 Hz, CF_2), 128.13, 128.46, 128.52, 128.84, 128.91, 129.01, 129.05, 130.99, 138.46, 138.81, 140.27 (aromatic C), 167.16 (C=O). − ^{19}F NMR (Et_2O): δ = −97.1 and −89.9 (ABq, J_{FF} = 191.7 Hz, J_{HF} = 14.3). − MS (70 eV); *m/z* (%): 423 (0.6) [M^+], 378 (0.6) [M^+ − EtO], 350 (20) [$M^+ - CO_2Et$], 77 (73) [Ph^+]. − $C_{25}H_{23}NF_2O_3$ (423.5): calcd. C 70.91, H 5.47, N 3.31; found C 70.91, H 5.45, N 3.32.

Ethyl 2,2,6-Triphenyl-5-oxomorpholine-3-carboxylate (**21**). Compound **21** was obtained quantitatively, by keeping the aziridine **18** in $CDCl_3$ solution for 2 days. Colorless prisms, m.p. 210−212 °C (CH_2Cl_2/ether). − IR (CCl_4): $\tilde{\nu}$ = 1760 cm^{-1} (OC=O), 1695 (NC=O). − ^1H NMR (C_6D_6): δ = 0.49 (t, *J* = 7.1 Hz, 3 H, CH_3), 3.50 (m, 2 H, OCH_2), 4.69 (d, *J* = 4.1 Hz, 1 H, 3-H), 5.05 (s, 1 H, 6-H), 6.8−8.00 (m, 15 H, aromatic H), 8.16 (d, *J* = 2.5 Hz, 1 H, NH). − ^{13}C NMR: δ = 13.38 (CH_3), 59.82 (C-3), 61.55 (CH_2), 76.21 (C-6), 79.80 (C-2), 126.26, 127.58, 127.68, 127.86, 128.40, 128.46, 128.68, 128.96, 129.06, 136.29, 139.54, 141.44 (aromatic C), 169.24 (C=O), 170.22 (C=O). − MS (70 eV); *m/z* (%): 328 (1) [$M^+ - CO_2Et$]. − $C_{25}H_{23}NO_4$ (401.5): calcd. C 74.80, H 5.77, N 3.49; found C 74.79, H 5.81, N 3.23.

[1] A. F. Khlebnikov, M. S. Novikov, R. R. Kostikov, in *Advances in Heterocyclic Chemistry* (Ed.: A. R. Katritzky), Academic Press, San Diego, **1996**, *65*, 93−233.
[2] A. F. Khlebnikov, M. S. Novikov, R. R. Kostikov, *Khim. Geterocycl. Soedin.* **1987**, 1336−1342; *Chem. Heterocycl. Comp.* **1987**, 1070−1076 (*Chem. Abstr.* **1988**, *109*, 37702a).
[3] M. S. Novikov, A. F. Khlebnikov, R. R. Kostikov, *Zh. Org. Khim.* **1988**, *24*, 1917−1922; *J. Org. Chem. USSR* **1988**, *24*, 1728−1732 (*Chem. Abstr.* **1989**, *110*, 192577c).
[4] A. F. Khlebnikov, M. S. Novikov, R. R. Kostikov, *Zh. Org. Khim.* **1990**, *26*, 1899−1903 *J. Org. Chem. USSR* **1990**, *26*, 1642−1645 (*Chem. Abstr.* **1991**, *114*, 246790v).

[5] M. S. Novikov, A. F. Khlebnikov, R. R. Kostikov, *Zh. Org. Khim.* **1996**, *32*, 667−674 (*Chem. Abstr.* **1997**, *126*, 47077r).
[6] A. F. Khlebnikov, T. Yu. Nikiforova, R. R. Kostikov, *Zh. Org. Khim.* **1996**, *32*, 746−760 (*Chem. Abstr.* **1997**, *126*, 59842z).
[7] A. F. Khlebnikov, E. I. Kostik, R. R. Kostikov, V. Y. Bespalov, *Khim. Geterocycl. Soedin.* **1990**, 355-362; *Chem. Heterocycl. Comp.* **1990**, 304−311 (*Chem. Abstr.* **1990**, *113*, 131933f).
[8] A. F. Khlebnikov, E. I. Kostik, R. R. Kostikov, *Synthesis* **1993**, 568−570.
[9] A. F. Khlebnikov, M. S. Novikov, R. R. Kostikov, *Zh. Org. Khim.* **1989**, *25*, 2332−2335; *J. Org. Chem. USSR* **1989**, *25*, 2103−2106 (*Chem. Abstr.* **1990**, *113*, 23311d).
[10] M. S. Novikov, A. F. Khlebnikov, A. E. Masalev, R. R. Kostikov, *Tetrahedron Lett.* **1997**, *38*, 4187−4190.
[11] H. P. Fritz, W. Z. Kornrumpf, *Z. Naturforsch.* **1981**, *36b*, 1375−1380.
[12] S. Hünig, Y. Keita, K. Peters, H.G. von Schnering, *Chem. Ber.* **1994**, *127*, 1495−1500.
[13] H. Aoyama, M. Sakamoto, K. Kuwabara, K. Yoshida, Y. Omote, *J. Am. Chem. Soc.* **1983**, *105*, 1958−1964.
[14] A. F. Khlebnikov, M. S. Novikov, R. R. Kostikov, *Mendeleev Comm.* **1997**, 145.
[15] J. R. McCarthy, C. L. Barney, M. J. O'Donnell, J. C. Huffman, *J. Chem. Soc., Chem. Commun*. **1987**, 469−470.
[16] N. V. Mashchenko, A. G. Matveeva, I. L. Odinets, E. I. Matrosov, E. S. Petrov, M. I. Terekhova, A. K. Matveev, T. A. Mastrukova, M. I. Kabachnik, *Zh. Obshch. Khim*. **1988**, *58*, 1973−1979 (*Chem. Abstr.* **1989**, *110*, 231004k).
[17] O. Tsuge, S. Kanemasa, K. Matsuda, *J. Org. Chem.* **1984**, *49*, 2688−2691.
[18] C. K. Ingold, C. L. Wilson, *J. Chem. Soc*. **1933**, 1493−1505.
[19] M. J. O'Donnell, R. L. Polt, *J. Org. Chem.* **1982**, *47*, 2663−2666.

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