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Rearrangement Reactions of Epoxides in the Presence of 2-Mercaptopyridine N-Oxide Sodium Salt.

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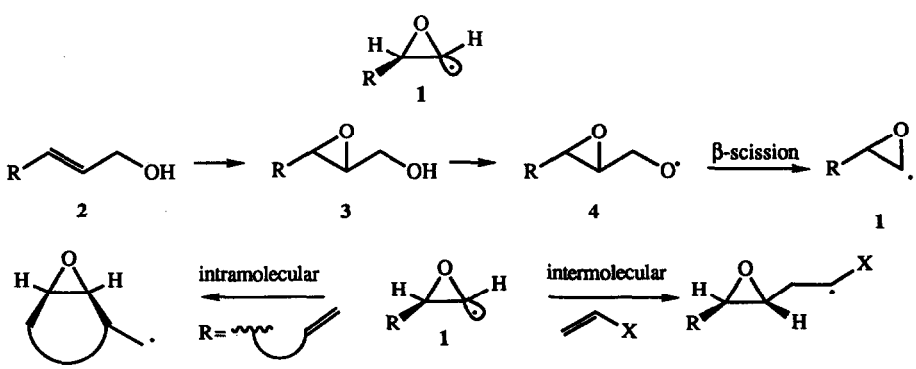
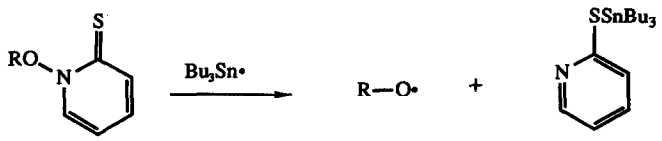
Abstract: Reaction of glycidyl bromides and tosylates with the sodium salt of mercaptopyridine N-oxide led to the formation of episulphides.

Stereospecificity in free radical reactions is an area of considerable current interest[1]. Oxiranyl radicals[2] have been shown to be capable of reacting with retention of stereochemistry, but their chemistry has been little exploited. They have been generated by abstrction of a halogen atom from halo-oxiranes, from decarbonylation of oxiranylacyl radicals and by hydrogen atom abstraction from appropriate oxiranes. Our interest in fragmentation chemistry led us to investigate alternative approaches. Our intention was to investigate the stereospecificity of reactions of (1) in both intra- and intermolecular reactions. A possible way to approach either enantiomer of (1) is to use epoxyalcohols (3), easily obtained by asymmetric epoxidation[3] of the appropriate allylic alcohol (2). Formation of oxyl radical (4) by standard routes[4] should then lead to a facile β-scission reaction to furnish the desired oxiranyl radical (1).



Scheme 1

Our first objective was to prepare alkoxy radicals (4) to determine the feasibility of the fragmentation approach to oxiranyl radicals (1), and at this stage we did not concern ourselves with enantiomerically pure epoxy alcohols (3). We selected Beckwith's method[4] utilising 2-mercaptopyridine-N-oxide sodium salt to give N-alkoxypyridinethiones (5), which are known to react with tri-*n*-butyltin hydride in a radical mediated reaction to give alkoxyl radical (6). Trapping of the oxiranyl radical was expected to occur *via* hydrogen atom abstraction from tributyltin hydride. As shown below, a series of intriguing rearrangements intercepted our plans.



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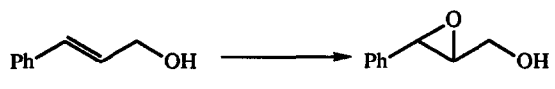
Cinnamyl alcohol (7) was converted to its epoxide (8) using vanadium acetylacetonate and t-butylhydroperoxide in refluxing benzene[5]. Conversion of (8) to the tosylate (9) was conveniently achieved using tosyl chloride in pyridine. However, the reaction of tosylate (9) with the sodium salt of 2-mercaptopyridine-N-oxide did not proceed as smoothly as was hoped. In DMF at 80°C the reaction gave a complex mixture of products, from which only low yields of the desired product (10) and an unexpected compound (11) could be isolated in pure form.



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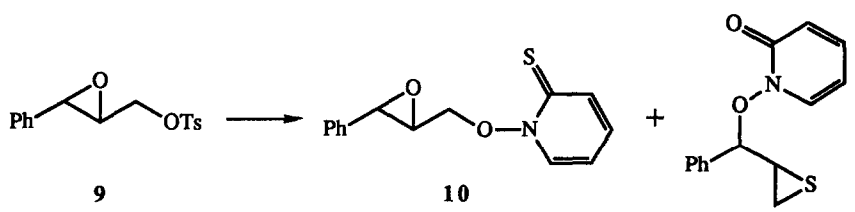

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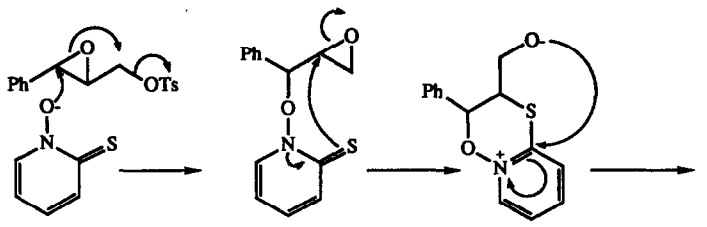
Beckwith has shown that mercaptopyridine N-oxide reacts on tetrahedral carbon as an oxygen-centred nucleophile in DMF. Hence, the formation of (11) in this reaction is rationalised as occurring *via* nucleophilic attack at the benzylic carbon atom of (9) to give epoxide (12). Clason *et al.*[6] and Sander[7] have noted that thioamides convert epoxides to episulphides, suggesting that (12) can rearrange *via* a 6-membered intermediate (13) to give the spiro compound (14). Subsequent rearrangement of (14) to (11) would be driven by the formation of the conjugated pyridone in (11). Attempts to increase the yield of the desired product (10), by replacement of tosylate with a better leaving group, triflate, did not meet with success. Only intractable reaction mixtures were obtained when alcohol (8) was reacted with triflic anhydride.



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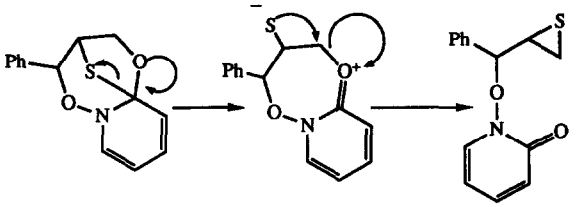
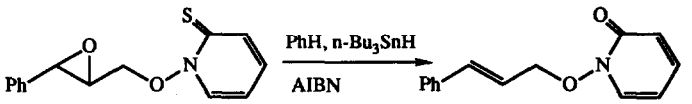


14 11

The reaction of (10) with tri-*n*-butyltin hydride, in refluxing benzene in the presence of catalytic quantities of AIBN, also gave a complex reaction mixture from which a single product (15) was isolated. The formation of (15) is proposed to occur by initial conversion of the epoxide to an episulphide (16), *via* a mechanism similar to that shown above . In the presence of tri-*n*-butyltin hydride, episulphide (16) is readily converted to the alkene (15)[8].



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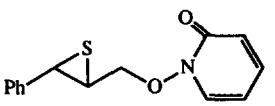

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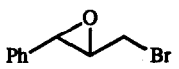
Three analogues of (9) in which a bromide was the leaving group (17, 19a and 19b) were next prepared. The epoxide (17) was prepared by reaction of cinnamyl bromide with *m*-chloroperoxybenzoic acid in dichloromethane while (19a) and (19b) were prepared by substitution of malonates (18a) and (18b) with 1,4-dibromo-2,3-epoxybut-2-ene. As expected, the reaction of (17) with the sodium salt of 2-mercaptopyridine-N-oxide gave a complex reaction mixture, from which only the episulphide (11) could be isolated. None of the epoxide (10) was present in this mixture. However, when (19a) and (19b) were reacted under the same conditions, the unrearranged episulphides (20a) and (20b) were isolated. We propose that the mechanism of the formation of (20a,b) is the same as that for (11), but with the initial nucleophilic

displacement occurring at the bromine-bearing carbon atom. This difference in reactivity may be caused by the fact that the initial displacement in (9) and (17) can occur at a benzylic carbon.



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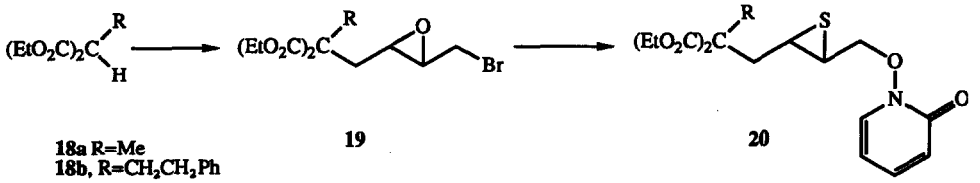

18a R=Me
18b, R=CH_2CH_2Ph

19

20

In conclusion, glycidyl bromides and tosylates have been shown to react with the sodium salt of 2-mercaptopyridine-N-oxide resulting in formation of episulphides. This type of rearrangement reaction has been demonstrated to be general by the isolation of episulphides (11), (20a) and (20b) as the sole isolable products from the reaction of 2-mercaptopyridine-N-oxide sodium salt and suitably substituted epoxides (9), (19a) and (19b).

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Experimental Section.

Infra-red spectra were obtained on a Pye-Unicam SP3-100 spectrometer. ^1H NMR spectra were recorded at 80MHz on a Bruker WP80SY, at 90MHz on a Perkin-Elmer R32, at 250 MHz on a Bruker WM 250, and at 400 MHz on a Bruker AM 400 instrument. ^{13}C NMR spectra were recorded at 22.5MHz on a Jeol FXC90Q, at 63 MHz on a Bruker WM 250 and at 100 MHz on a Bruker AM 400 instrument. All NMR experiments were carried out in $CDCl_3$ with tetramethylsilane as internal reference unless otherwise stated. Mass spectra were recorded on a VG micromas 70E or an AEI MS902 instrument. All solvents were distilled before use. Tetrahydrofuran was distilled from potassium-benzophenone. Chromatography was performed on Kieselgel 60 (Fluka).

2-Hydroxymethyl-3-phenyloxirane (8)

To 3-phenylprop-2-enol (10g, 0.075mol) in benzene (350ml), vanadium acetylacetonate (300mg) was added and the mixture brought to reflux. t-Butylhydroperoxide (10.35ml, 0.0825mol) was added dropwise over 1 hour and the solution heated under reflux for a further 3h. The cooled mixture was washed with saturated sodium thiosulphate solution (5x100ml), dried over anhydrous sodium sulphate, filtered and evaporated to dryness to give a brown oil which was purified by chromatography on silica gel (1:2 ethyl acetate:petrol) to yield 2-hydroxymethyl-3-phenyloxirane (8) as a clear oil, (6.60g, 59%). (Found $\underline{M}^+$, 150.0653. $C_9H_{10}O_2$ requires $\underline{M}$, 150.0681); υ_{max} (film) 3 400, 3 010, 2 995, 1 610, 1 498, 1 460, 1 205,

1 070, 890, 750, 700 cm^{-1}; δ_H (90MHz, $CDCl_3$) 3.15 (1H, m, C*H*O), 3.40 (1H, s, O*H*), 3.55-4.05 (3H, m, CH_2C*H*O), 7.15-7.25 (5H, m, Ar*H*); m/z (EI^+) 150 (M^+, 5%), 132 (11), 119 (16), 107 (40), 90 (42).

2-(4-Methylphenylsulphonyloxy)methyl-3-phenyloxirane (9)

To 2-hydroxymethyl-3-phenyloxirane (8) (4.20g, 0.028 mol) in pyridine (50 ml) at 0°C, 4-methylphenylsulphonyl chloride (5.89g, 0.031 mol) was added and the mixture stirred for 7 hours. Then ether (50 ml) was added and the solution was washed with saturated copper (II) sulphate (5x50ml), dried over anhydrous sodium sulphate, filtered and evaporated to dryness to yield a yellow oil (5.3g), which was purified by chromatography on silica gel (1:4 ethyl acetate:hexane) to give *2-(4-*methylphenylsulphonyloxy)methyl-3-phenyloxirane (9) as a clear oil, (1.1g, 13%). (Found C, 63.20; H, 5.54. $C_{16}H_{16}SO_4$ requires C, 63.16; H, 5.26); υ_{max} (disc) 3 035, 3 008, 2 960, 1 599, 1 497, 1 368, 1 240, 1 177, 891, 815, 791 cm^{-1}; δ_H (250MHz, $CDCl_3$) 2.44 (3H, s, CH_3), 3.20-3.29 (1H, m, C*H*CH_2), 3.74 (1H, d, *J* 2.0 Hz, C*H*Ph), 4.01-4.45 (2H, m, CH_2), 7.12-7.38 (7H, m, Ar*H*), 7.82 (2H, d, *J* 8.4 Hz, Ar*H*); δ_C (22.5MHz, $CDCl_3$) 21.41, 56.24, 58.36, 69.46, 125.64, 127.81, 128.40, 129.87, 132.85, 135.61, 145.03 ppm; m/z (EI^+) 188 (11%), 186 (27), 127 (39), 125 (100), 91 (64).

N-(3-Phenyl-2,3-epoxypropyloxy)pyridine-2-thione (10) and (ii)- *N-(3-phenyl-2,3-epithiopropyloxy) pyrid-2-one* (11)

To 2-(4-methylphenylsulphonyloxy)methyl-3-phenyloxirane (9) (1g, 3.29mmol) in dry dimethylformamide (20ml), 2-mercaptopyridine-N-oxide sodium salt (3.29mmol, 494mg) was added and the mixture was heated at 80°C, under argon, with minimum exposure to light for 5h. The reaction mixture was poured into sodium hydroxide solution (0.1N, 50ml) and extracted with diethyl ether (5x50ml). The organic phase was washed with water (50ml) and brine (50ml) and dried over anhydrous sodium sulphate, filtered and evaporated to dryness. The oily product was purified by chromatography on silica gel (polarity gradient: 1:4 ethyl acetate:petrol, to ethyl acetate, and then 1:1 ethyl acetate:methanol), to yield two products: (i)-*3-phenyl-2,3-epoxypropyloxypyridine-2-thione* (10) as a clear oil, (60mg, 7%). (Found MH^+, 260.0745. $C_{14}H_{13}NO_2S$ requires MH, 260.0745); υ_{max} ($CHCl_3$) 3 037, 2 965, 1 721, 1 663, 1 591, 1 241, 765, 728, 721 cm^{-1}; δ_H (80MHz, $CDCl_3$) 3.20-3.55 (1H, m, CH_2C*H*O), 3.61-3.73 (1H, d, *J* 4.9 Hz, C*H*Ar), 4.55 (2H, d, *J* 6.4 Hz, CH_2), 6.03 (1H, dt, *J* 7.0, 1.7Hz, Ar*H*), 6.66 (1H, dd, *J* 1.3, 9.1 Hz, Ar*H*), 7.10-7.63 (7H, m, Ar*H*); δ_C (22.5MHz, $CDCl_3$) 38.20, 42.10, 78.56, 104.89, 122.77, 126.83, 127.86, 128.46, 136.04, 137.28, 138.59, 158.42 ppm; m/z (FAB) 260 (MH^+, 29%), 150 (12), 149 (69), 133 (10), 117 (37), 109 (12).

and (ii)- *N-(3-phenyl-2,3-epithiopropyloxy)pyrid-2-one* (11) as a brown oil. (85mg, 10%). (Found MH^+, 260.0745. $C_{14}H_{13}NO_2S$ requires MH, 260.0745); υ_{max} (film) 3 060, 2 995, 1 660, 1 580, 1 530, 1 280, 760, 710 cm^{-1}; δ_H (400MHz, $CDCl_3$) 2.22 (1H, dd, *J* 1.6, 5.3 Hz, CH_2), 2.43 (1H, dd, *J* 1.6, 6.6 Hz, CH_2), 3.35-3.40 (1H, m, C*H*CH_2), 5.13 (1H, d, *J* 8.1 Hz, C*H*Ar), 5.98 (1H, dt, *J* 6.9, 1.6 Hz, Ar*H*), 6.10 (1H, dd, *J* 1.6, 9.1 Hz, Ar*H*), 7.23-7.53 (7H, m, Ar*H*); δ_C (100MHz, $CDCl_3$) 20.07, 34.19, 89.89, 104.36, 122.64, 127.91, 128.81, 129.54, 136.49, 137.14, 138.62, 158.91 ppm; m/z (FAB) 260 (MH^+, 11%), 259 (3), 150 (11), 149 (100), 117 (44), 95 (29).

N-(3-Phenylprop-2-enyloxy)-pyrid-2-one (15).

To *phenyloxiran-2-ylmethoxypyridine-2-thione* (10) (52.1mg, 0.2mmol) in refluxing benzene (20ml), tri-n-butyltin hydride (0.24mmol, 0.064ml) and AIBN (5mg) in benzene (10ml) were added dropwise, under nitrogen, over 1h. The mixture was heated under reflux for a further 4 h, evaporated to dryness and purified by chromatography on silica gel (1:1 ethyl acetate:dichloromethane) to yield *N-(3-phenylprop-2-enyloxy)-pyrid-2-one*(15) as a clear oil, (15.8mg, 34%). (Found $\underline{M}^+$-C_5H_4NO 133.0606. C_9H_9O requires $\underline{M}$, 133.0653); υ_{max} [9](film) 3 010, 2 998, 2 928, 1 661, 1 588, 1 102, 751, 743 cm^{-1}; δ_H (400MHz, $CDCl_3$) 4.93 (2H, dd, *J* 1.0, 7.2 Hz, CH_2), 6.07 (1H, dt, *J* 6.7, 1.7, Ar*H*), 6.38 (1H, dt, *J* 7.2, 15.8 Hz, =$CH$$CH_2$), 6.64-6.70 (2H, m, CH= and Ar*H*), 7.26-7.47 (7H, m, Ar*H*); δ_C (100MHz, $CDCl_3$) 76.79, 104.81, 121.27, 122.89, 126.90, 128.62, 128.74, 135.83, 136.74, 138.15, 138.72, 159.04 ppm; m/z (FAB) 228 ($\underline{MH}^+$, 52%), 227 (10), 149 (12), 133 (14), 132 (12), 117 (100), 96 (33), 95 (19), 79 (28).

3-Bromomethyl-2-phenyloxirane (17)

To 3-bromo-1-phenylpropene (3.7g, 0.019 mol) in dichloromethane (50 ml), m-chloroperbenzoic acid (85%, 4.24g, 0.021 mol) was added and the mixture was stirred for 5 days at room temperature. The reaction mixture was evaporated to dryness, dissolved in ether (50ml) and washed with sodium sulphite (3x50ml). The aqueous layer was back-extracted with ether (3x50ml) and the combined organic phases were dried over anhydrous sodium sulphate, filtered and evaporated to dryness to yield 3-bromomethyl-2-phenyloxirane (17) as a white solid, (3.6g, 88%).m.p. 46°C. (Found $\underline{M}^+$, 213.9821. C_9H_9BrO requires $\underline{M}$, 213.9817); υ_{max} ($CHCl_3$) 3 040, 2 932, 1 601, 1 577, 1 455, 1 256, 905, 800 cm^{-1}; δ_H (90MHz, $CDCl_3$) 3.25-3.45 (1H, m, CHO), 3.55-3.70 (1H, m, CHO), 3.80-4.00 (2H, m, CH_2Br), 7.25-7.60 (5H, m, Ar*H*); m/z (EI^+) 214 ($\underline{M}^+$, 9%), 212 (11), 133 (100), 119 (27), 107 (13), 91 (89), 77 (69).

N-(3-Phenyl-2,3-epithiopropyloxy)pyrid-2-one (11)

To 3-bromomethyl-2-phenyloxirane (17) (639mg, 3mmol) in dimethylformamide (5ml), 2-mercaptopyridine-N-oxide sodium salt (450mg, 3mmol) was added and the mixture was heated at 80°C under argon for 16 hours with minimum exposure to light. The cooled reaction mixture was diluted with aqueous sodium hydroxide (0.1 N, 20ml) and extracted with ether (5x50ml). The organic phases were combined, washed with water (20ml) and brine (20ml) and dried over anhydrous sodium sulphate, filtered and evaporated to dryness to give a clear oil which was purified by chromatography on silica gel (polarity gradient: hexane to ethyl acetate in 1% increments to ethyl acetate:hexane (1:9) and then ethyl acetate), to yield *N-(3-phenyl-2,3-epithiopropyloxy)pyrid-2-one* (11) as a brown oil. (85mg, 11%). (Found $\underline{MH}^+$, 260.0745. $C_{14}H_{13}NO_2S$ requires $\underline{MH}$, 260.0745); υ_{max} (film) 3 060, 2 995, 1 660, 1 580, 1 530, 1 280, 760, 710 cm^{-1}; δ_H (400MHz, $CDCl_3$) 2.22 (1H, dd, *J* 1.6, 5.3 Hz, CH_2), 2.43 (1H, dd, *J* 1.6, 6.6 Hz, CH_2), 3.35-3.40 (1H, m, $CHCH_2$), 5.13 (1H, d, *J* 8.1 Hz, CHAr), 5.98 (1H, dt, *J* 6.9, 1.6 Hz, Ar*H*), 6.10 (1H, dd, *J* 1.6, 9.1 Hz, Ar*H*), 7.23-7.53 (7H, m, Ar*H*); δ_C (100MHz, $CDCl_3$) 20.07, 34.19, 89.89, 104.36, 122.64, 127.91, 128.81, 129.54, 136.49, 137.14, 138.62, 158.91 ppm; m/z (FAB) 260 ($\underline{MH}^+$, 11%), 259 (3), 150 (11), 149 (100), 117 (44), 95 (29)

Ethyl-6-bromo-2-carbethoxy-4,5-epoxy-2-methyl-hexanoate (19a)

To sodium hydride (60%, 6.6mmol, 264mg) in tetrahydrofuran (20ml), diethyl methylmalonate (3mmol, 0.52g) was added and the mixture was stirred for 0.5h. 1,4-dibromo-2,3-epoxybutane (3.3mmol, 759mg) was added and the mixture was heated under reflux under nitrogen for 16h. The reaction mixture was diluted with ethyl acetate (50ml) and washed with 10% hydrochloric acid (50ml), dried over anhydrous sodium sulphate, filtered and evaporated to give an oil that was purified by chromatography on silica gel (ethyl acetate:petrol (1:9)) to yield *ethyl-6-bromo-2-carbethoxy-4,5-epoxy-2-methyl-hexanoate* (19a) as a yellow oil, (406mg, 42%). (Found MH$^+$, 323.0494. $C_{12}H_{19}BrO_5$ requires MH, 323.0494); υ_{max} (film) 2 990, 2 920, 1 730, 1 250, 1 120, 1 023, 733 cm^{-1}; δ_H (400MHz, $CDCl_3$)(mixture of diastereoisomers apparent; peaks due to minor isomer are so designated below) 1.26 (3H, t, *J* 7.1 Hz, CH_3), 1.27 (3H, t, *J* 7.1 Hz, CH_3), 1.53 (3H, s, CH_3), 1.54 (3H (minor), s, CH_3), 1.90 (1H (minor), dd, *J* 7.9, 14.7 Hz, CH_2C), 2.03 (1H, dd, *J* 6.6, 14.4 Hz, CH_2C), 2.18 (1H, dd, *J* 5.0, 14.4 Hz, CH_2C), 2.34 (1H (minor), dd, *J* 3.7, 14.7 Hz, CH_2C), 2.96-3.05 (2H, m, *CHOCH*), 3.16-3.51 (2H, m, CH_2Br), 4.20 (2H, q, *J* 7.1 Hz, CH_2CH_3), 4.22 (2H, q, *J* 7.1 Hz, CH_2. δ_C (22.5MHz, $CDCl_3$) 13.83, 20.27, 28.67, 31.75, 33.49, 37.93, 52.34, 55.00, 56.68, 56.89, 61.39, 171.31 ppm; m/z (FAB) 325 (MH$^+$, 31%), 324 (6), 323 (35), 322 (1), 243 (11).

Ethyl-6-bromo-2-carbethoxy--4,5-epoxy-2-(2-phenylethyl)-hexanoate (19b)

To sodium hydride (60%, 3.6mmol, 144mg) in tetrahydrofuran (20ml), diethyl (2-phenylethyl)malonate (3mmol, 792mg) was added and the solution was stirred for 0.5h. To the solution, 2,3-bisbromomethyloxirane (3.6mmol, 828mg) was added and the mixture was refluxed for 16h under nitrogen. The reaction mixture was diluted with ethyl acetate (50ml) and washed with 10% hydrochloric acid (50ml) and dried over anhydrous sodium sulphate, filtered and evaporated to dryness to give a clear yellow oil which was purified by chromatography on silica gel (ethyl acetate:petrol (1:9)) to yield *ethyl-6-bromo-2-carbethoxy--4,5-epoxy-2-(2-phenylethyl)-hexanoate* (19b) as a clear oil, (389mg, 31.5%). (Found MH$^+$, 413.0964. $C_{19}H_{25}BrO_5$ requires MH, 413.0964); υ_{max} (film) 3 027, 2 981, 1 729, 1 604, 1 497, 1 240, 1 183, 911, 752, 701, 659 cm^{-1}; δ_H (400MHz, $CDCl_3$) (mixture of diastereoisomers)1.27 (6H (minor), t, *J* 7.1 Hz, CH_3), 1.28 (3H, t, *J* 7.1 Hz, CH_3), 1.98 (1H (minor), dd, *J* 8.5, 15.1 Hz, CH_2C), 2.10 (1H, dd, *J* 7.1, 14.8 Hz, CH_2C), 2.26-2.68 (5H, m, CH_2CH_2Ph and CH_2C), 2.92-3.19 (2H, m, *CHOCH*), 3.25-3.40 (2H, m, CH_2Br), 4.17-4.27 (4H, m, CH_2CH_3), 7.16-7.32 (5H, m, Ar*H*); δ_C (90MHz, $CDCl_3$) 13.99, 30.73, 31.76, 35.33, 55.05, 56.41, 56.62, 57.00, 61.50, 126.07, 128.35, 141.13, 170.66 ppm; m/z (FAB) 415 (MH$^+$, 40%), 414 (9), 413 (40), 412 (2), 333 (8).

N-(5,5-Dicarbethoxy-2,3-epithio hexyloxy)-pyrid-2-one (20a)

To oxirane (19a) (322mg, 1mmol) in dimethylformamide (6ml), 2-mercaptopyridine-N-oxide sodium salt (1mmol, 150mg) was added and the mixture was heated at 80°C, under argon for 6 h. The solution was then diluted with dichloromethane and washed with 0.1N sodium hydroxide (3x15ml), dried over anhydrous sodium sulphate, filtered and evaporated to dryness. The oily residue was purified by chromatography on silica gel (polarity gradient: ethyl acetate to ethyl acetate:methanol (1:9)) to yield *(N-(5,5-dicarbethoxy-2,3-epithio hexyloxy)-pyrid-2-one* (20a) as a clear oil (12.5 mg, 4%). (Found MH$^+$, 370.1324. $C_{17}H_{23}NO_6S$ requires MH, 370.1324); δ_H (400MHz, $CDCl_3$) 1.25 (6H, m, CH_3CH_2), 1.52

(3H, s, CH_3), 2.15 (1H, dd, *J* 6.9, 14.5 Hz, CH_2C), 2.35 (1H, dd, *J* 6.2, 14.5 Hz, CH_2C), 2.75 (1H, m, C*H*SCH_2C), 2.95 (1H, m, C*H*SCH_2O), 4.20 (5H, m, CH_2CH_3 and CH_2O), 4.43 (1H, dd, *J* 6.4, 10.8 Hz, CH_2O), 6.15 (1H,m, Ar*H*), 6.70 (1H, m, Ar*H*), 7.35 (1H, m, Ar*H*), 7.55 (1H, m, Ar*H*); δ_C (100MHz, $CDCl_3$) 14.00, 20.06, 20.26, 33.04, 34.70, 35.86, 36.24, 36.54, 41.34, 53.59, 61.59, 80.26, 105.17, 105.25, 122.95, 123.04, 136.03, 136.10, 138.82, 138.98, 158.68, 171.49, 171.52 ppm; m/z (FAB) 370 (MH^+, 17%),369 (2), 259 (100).

N-(5,5-Dicarbethoxy-7-phenyl-2,3-epithioheptyloxy)-pyrid-2-one (20b)

To oxirane (19b) (300mg, 0.73 mmol) in dimethylformamide (5ml), 2-mercapto-pyridine-N-oxide sodium salt (0.73mmol, 109.5mg) was added and the mixture was heated at 80°C, under argon for 6 hours. The solution was then diluted with dichloromethane and washed with 0.1N sodium hydroxide (3x15ml), dried over anhydrous sodium sulphate, filtered and evaporated to dryness. The oily residue was purified by chromatography on silica gel (polarity gradient: ethyl acetate to ethyl acetate:methanol (9:1)) to yield *N-(5,5-Dicarbethoxy-7-phenyl-2,3-epithioheptyloxy)-pyrid-2-one* (20b) as a clear oil, (18.2 mg, 6%). (Found MH^+, 460.1794. $C_{24}H_{29}NO_6S$ requires MH, 460.1794); δ_H (400MHz, $CDCl_3$) 1.26-1.29 (6H, m, CH_3), 2.18 (1H, dd, *J* 7.4, 14.8 Hz, CH_2C), 2.27-2.39 (3H, m, CH_2CH_2Ph and CH_2C), 2.46-2.59 (2H, m, CH_2Ph), 2.66-2.71 (1H, m, C*H*S), 2.95-2.99 (1H, m, C*H*S), 4.20-4.34 (5H, m, [CH_2CH_3] x 2 and CH_2O), 4.41-4.51 (1H, m, CH_2O), 6.12-6.18 (1H, m, Ar*H*), 6.66-6.71 (1H, m, Ar*H*), 7.16-7.32 (7H, m, Ar*H*), 7.52 (1H, d, *J* 6.6 Hz, Ar*H*); δ_C (100MHz, $CDCl_3$) 13.78, 29.40, 30.35, 34.20, 34.56, 35.43, 36.03, 38.15, 57.06, 57.20, 61.30, 61.35, 79.91, 104.84, 104.97, 122.64, 122.77, 128.06, 128.20, 135.73, 135.84, 138.51, 140.67, 158.37, 170.45. ppm; m/z (FAB) 460 (MH^+, 3%), 349 (16).

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