Synthetic Ionophores. Part 7.[1,2] Synthesis and Ionophore Character of Uracil based Podands

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6-Methyl-1,3-oxazine-2,4(3*H*)-dione reacts with α,ω-dihalides under PTC conditions to give the 3,3'-(α,ω-dialkylene)bis[6-methyl-1,3-oxazine-2,4(3*H*)-diones] **3**, **11**, **17**. Further reactions of the latter with amines provide the bis(uracil) podands **5–10**, **12–14**, **18**, **19** with different spacers between N-3 and functionalized alkyl appendages at N-1. The podands **5–10**, **14**, **18** and **19** are effective ionophores and **18** selectively extracts and transports Tl^+ picrate, over Li^+, Na^+, K^+ and $\overset{+}{N}H_4$ picrates, across a chloroform membrane.

Since macrocycles possessing five-membered cyclic urea-type binding site(s) have been little studied,[3–7] we have designed the podands **1**, where two uracil units linked at N-3 with various spacers (open-chain and cyclic) have flexible chains equipped with varied terminal binding groups at N-1. CPK models of **1** [X = CH_2, and X = $(CH_2)_2$] show overlap between the two C-2 carbonyl oxygens of the uracils, which would inhibit cavity induced ligation, whilst only **1** [X ≥ $(CH_2)_4$] displays sufficient flexibility to form variable pseudocavities with four heteroatoms. Compounds **1** [X = $(CH_2)_2O(CH_2)_2$ and 2-methoxy-5-methyl-1,3-phenylenedimethylene] have an additional ligating site and a cavitand type structure is evident from a CPK model of the latter. By incorporating these parameters (preorganization together with flexibility) into suitable structures it is possible to synthesize compounds which may take part in a complexation–decomplexation equilibrium favourable to selective ion-transport.[8] Of the 11 such podands **5–10**, **12–14**, **18–19** synthesized, the podand **18** transports Tl^+, with remarkable selectivity over Li^+, Na^+, K^+ and $\overset{+}{N}H_4$ picrates, across a chloroform membrane.

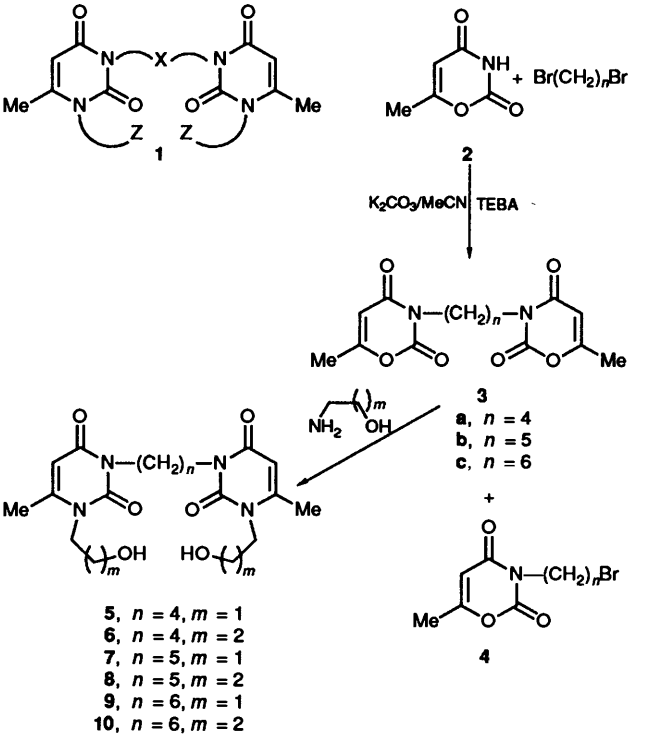
6-Methyl-1,3-oxazine-2,4(3*H*)-dione **2** reacts with 1,4-dibromobutane,† under phase transfer catalytic conditions [MeCN–K_2CO_3–$Et_3(PhCH_2)NCl$] to give two products. That of lower R_f obtained by crystallization from EtOH [(50%), m.p. 157 °C, *m/z* 308 (M^+); δ_H 2.17 (s, 6 H), 5.67 (s, 2 H), 3.83 (t, 4 H) 1.50–1.87 (4 H, m)] was identified as compound **3a** and that of higher R_f isolated from the mother liquor [(5%) m.p. 68 °C, *m/z* 263 and 261 (M^+, Br present); δ_H 3.34 and 3.85 (both t, 2 H), 2.15 (s, 3 H), 5.66 (s, 1 H) and 1.45–2.00 (m, 4 H)] was identified as compound **4a**. Compound **3a** when heated with 2-aminoethanol gives the podand **5a**.‡

Similarly, **3a** with 3-aminopropan-1-ol gave the podand **6**, but it did not react with 2-aminophenol.

Compound **2** reacts with 1,5-dibromopentane and 1,6-dibromohexane to give compounds **3b** (+ < 5%, **4b**) and **3c** respectively. The latter with 2-aminoethanol and 3-aminopropan-1-ol gives the podands **7** and **8**, and **9** and **10**, respectively. The podands **5**, **6**, **9** and **10** with an even number of carbon spacers between the two 6-methyluracil moieties crystallize rapidly from water and have higher m.p.s than the podands **7** and **8**, bearing an odd number of carbon spacers.

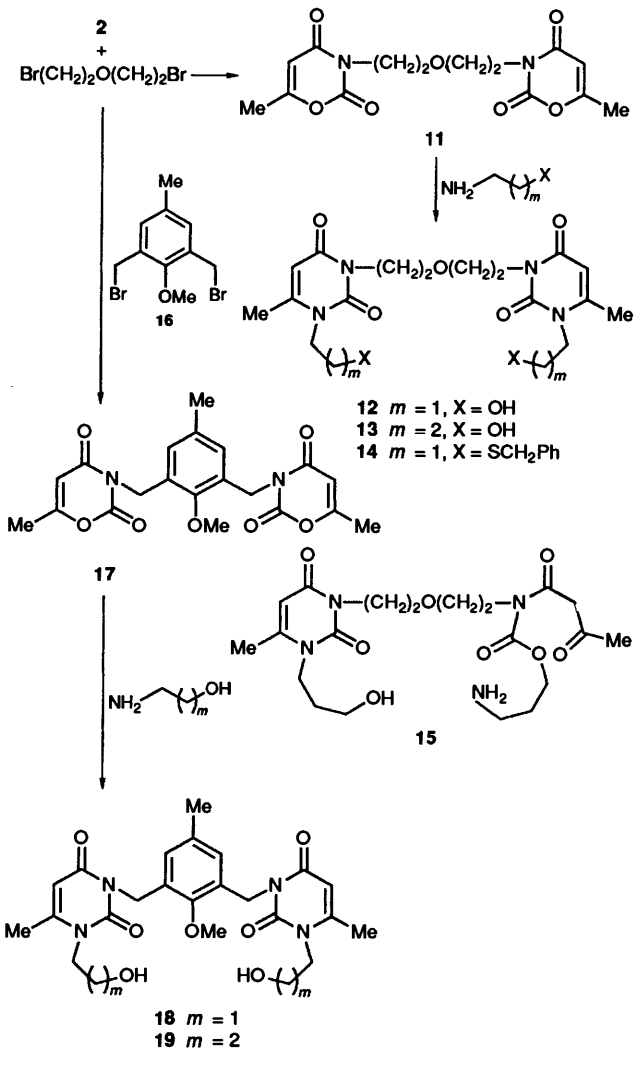
Bis(2-bromoethyl) ether fails to react with **2** in MeCN–K_2CO_3–$Et_3(PhCH_2)NCl$, but does so in DMF–K_2CO_3–$Et_3(PhCH_2)NCl$ to give compound **11** (50%); this when heated with 2-aminoethanol and 2-benzylthioethylamine gives the podands **12** and **14**, respectively. Compound **11** when heated with 3-aminopropan-1-ol gives two products. That with the higher R_f was identified as compound **15** [(20%), m.p. 113 °C; δ 1.88 (4 H quint.), 2.28 and 2.32 (both 2 H, s), 3.26 (1 H, br) and 7.35 (2 H, br) (both exchangeable), 4.03 and 4.17 (both 2 H, t), 5.65 (1 H, s); δ 3.36–3.74 (14 H, m); the off resonance ^1H decoupled ^{13}C NMR spectrum showed 2 × q, 9 × t, 1 d and 6 × s; no M^+, 413 ($M^+ - CH_3CO$) and 371 ($M^+ - CH_3COCH_2CO$)]. Here, one oxazine unit of **11** reacts with the NH_2[8] of 3-aminopropan-1-ol to give the pyrimidine ring whilst the other unit reacts with the OH[9] at C-2 to give the carbamate derivative. The spectral data for the component of lower R_f supports structure **13**.

Further, compound **2** reacts with 3,5-bis(bromomethyl)-4-methoxytoluene **16** in DMF–K_2CO_3–$Et_3(PhCH_2)NCl$ to give compound **17** (40%), which when heated with 2-aminoethanol and 3-aminopropan-1-ol gives the podands **18** and **19** respectively.



† Compound **2** does not react with bromochloromethane and with 1,2-dibromoethane and 1,3-dibromopropane gives only 3-(ω-bromoalkyl)-1,3-oxazine-2,4(3*H*)-diones, the corresponding derivatives of **3** not being formed.

‡ In an alternative approach, 1-(2-hydroxyethyl)-6-methyluracil with 1,4-dibromobutane gives **5** in only 5% yield along with other products.



Extraction and Transport Studies.—Since facilitated transport of cations across a lipophilic membrane involves extraction (complexation) and release (decomplexation) of the cation, determination of the ionophore-induced extraction from an aqueous into a lipophilic phase is a direct index of the transport properties of the ionophore. Hence, in the present study, we have determined the extraction (Table 1) and transport (Table 2) rates of Li^+, Na^+, K^+, Tl^+ and $\overset{+}{N}H_4$ picrates with the podands **5–10**, **12–14**, **18** and **19** with chloroform as the non-polar membrene.

The podands **5**, **6**, **9** and **10** with an even number of carbon spacers between two 6-methyluracils show different trends in their extraction constants as compared with the podands **7** and **8**, bearing an odd number. Podands **5** and **9** with a 2-hydroxyethyl substituent at N-1 extract metal picrates better than the corresponding podands **6** and **10** possessing a 3-hydroxypropyl substituent. For podands with five-carbon spacers, **7** containing a $(CH_2)_2OH$ unit extracts less well than **8** containing $(CH_2)_3OH$. Further, the podands **5**, **6**, **9** and **10** show better Tl^+/K^+ extraction selectivity than Tl^+/Na^+, but the podands **7** and **8** extract Na^+ marginally better than K^+ and Tl^+. The ion transport rates for the podands **5–10**, do not, in general, parallel the extraction rates. The ligands **5** and **6** transport $\overset{+}{N}H_4$ and Li^+, respectively, more efficiently than other metal picrates whilst the increased lipophilicity of the podands **9** and **10** in comparison with the podands **5–8** increases their transport rates.

Whilst an increase in the number of hetero atoms (binding sites), enhances a ligand's extraction [10] and transport [11] ability, here, the additional oxygen increases the solubility of the podands **12** and **13** in water, thus making them poor ionophores. The podand **14** having three oxygens and two sulfur atoms as ligating sites, is much more lipophilic than the podands **12** and **13**, extracting and transporting metal cations more efficiently, but lacking selectivity towards any cation.

The enhanced lipophilic character of the podands **18** and **19** arises from replacement of the spacer $(CH_2)_2O(CH_2)_2$ of podands **12** and **13** with the 2-methoxy-5-methyl-1,3-phenylenedimethylene unit, the former with five heteroatom binding sites, both transporting and extracting metal picrates better than all other podands. Here, also, like the other five carbon spacer podands **7** and **8**, the podand **19** with a 3-hydroxypropyl group, both extracts and transports metal picrates better than the podand **18**, with its 2-hydroxyethyl substituent. However, the podand **18** shows better selectivity towards Tl^+ than the podand **19**. Compound **18** has an extraction ratio of *ca.* 3:1 in favour of Tl^+ picrate over Na^+, K^+ and $\overset{+}{N}H_4$ picrates, whereas the ratio for the podand **19** is 1.1–1.5:1. However, the podand **18** has a transport rate for Tl^+ picrate nearly 10, 14, 25 and 8.5 times greater than Li^+, Na^+, K^+ and $\overset{+}{N}H_4$ picrates, respectively.

Thus, the presence of a two-carbon unit at N-1 of 6-methyluracil in podands **5**, **7**, **9** and **18** favours the extraction and transport of Tl^+ picrate, over Li^+, Na^+, K^+ and $\overset{+}{N}H_4$ picrates, to a greater extent than their analogues **6**, **18**, **10** and **19** with three-carbon chains. The podand **18**, shows highest transport selectivity towards Tl^+ picrate over Li^+, Na^+, K^+ and $\overset{+}{N}H_4$ picrates and can be used for separation of toxic Tl^+ from the biologically and chemically similar [12] potassium ion.

Experimental

^1H and ^{13}C NMR spectra were recorded on JNM PMX 60 and Bruker AC 200 instruments using TMS as an internal standard. Mass spectra (70 eV) and IR spectra were taken on JEOL JMS-D 300 and PYE UNICAM SP3-300 instruments respectively. M.p.s are uncorrected. Silica gel coated plates and columns were used for monitoring the reactions and purification of the products, respectively. 6-Methyl-1,3-oxazine-2,4(3*H*)-dione was prepared by the reported method.[8] The transport experiments were performed on a poly electromagnetic stirrer possessing six positions for rotation of six magnetic bars placed in different apparatus sets, at a constant speed (150 ± 5 r.p.m.).

Reactions of 6-Methyl-1,3-oxazine-2,4(3H)-dione **2** *with α,ω-Dihalides: Formation of Compounds* **3a–c**, **11** *and* **17**.—*General procedure.* A solution of compound **2** (2.5 g, 20 mmol) and 1,4-dibromobutane (2.38 g, 12 mmol) in acetonitrile containing K_2CO_3 (anhydrous) and triethyl(benzyl)ammonium chloride (TEBA Cl), was stirred for 2–3 h in an oil-bath. After the completion of the reaction (TLC), the mixture was filtered and the residue was washed with ethyl acetate. The combined filtrate and washings were distilled off and the residue was crystallized from ethanol to give **3a**. Chromatography of the mother liquor over silica gel column gave compound **4a**. Similarly, **2** with 1,5-dibromopentane and 1,6-dibromohexane gave compounds **3b**, **4b** and **3c** respectively.

Compound **2** reacted with bis-(2-bromoethyl) ether and 3,5-bis(bromomethyl)-4-methoxytoluene **16** in dimethylformamide under similar conditions to give compounds **11** and **17**, respectively, the data for which are given below.

3,3′-*Tetramethylenebis*[6-*methyl*-1,3-*oxazine*-2,4(3H)-*dione*] **3a** (50%), m.p. 157 °C (ethanol); *m/z* 308 (M^+) and 265 ($M^+ - CH_3CO$); $\delta_H(CDCl_3)$ 1.50–1.87 (m, 4 H, 2 × CH_2), 2.17 (s, 6 H,

2 × CH_3), 3.83 (t, *J* 7, 4 H, 2 × CH_2) and 5.67 (s, 2 H, 2 × 5-H); ν_{max}(KBr)/cm^{-1} 1740 (C=O), 1700 (C=O) and 1660 (C=C); λ_{max}(EtOH)/nm 230 (ε 4.18 × 10^3) and 272 (ε 2.76 × 10^2) (Found: C, 54.95; H, 5.1; N, 9.0. $C_{14}H_{16}N_2O_6$ requires C, 54.55; H, 5.19; N, 9.09%).

3-(4-*Bromobutyl*)-6-*methyl*-1,3-*oxazine*-2,4(3H)-*dione* **4a** (5%), m.p. 68 °C (ethanol); *m*/*z* 263 and 261 (M^+) (1:1); δ_H($CDCl_3$) 1.45–2.00 (m, 4 H, 2 × CH_2), 2.15 (s, 3 H, CH_3), 3.34 (t, *J* 6, 2 H, NCH_2), 3.85 (t, *J* 6, 2 H, $BrCH_2$), 5.66 (s, 1 H, 5-H); ν_{max}(KBr)/cm^{-1} 1740 (C=O), 1700 (C=O) and 1660 (C=C) (Found: C, 41.2; H, 4.3; N, 5.1. $C_{19}H_{12}BrNO_3$ requires C, 41.22; H, 4.58; N, 5.34%).

3,3′-*Pentamethylenebis*[6-*methyl*-1,3-*oxazine*-2,4(3H)-*dione*] **3b** (31%), m.p. 139 °C (ethanol); *m*/*z* 322 (M^+); δ_H($CDCl_3$) 1.65–1.83 (m, 6 H, 3 × CH_2), 2.17 (s, 6 H, 2 × CH_3), 3.83 (t, *J* 7, 4 H, 2 × N-CH_2) and 5.59 (s, 2 H, 2 × 5-H); ν_{max}(KBr)/cm^{-1} 1750 (C=O), 1710 (C=O) and 1660 (C=C); λ_{max}(EtOH)/nm 230 (ε 4.51 × 10^3) and 272 (ε 6.7 × 10^2) (Found: C, 55.7; H, 5.5; N, 8.7. $C_{15}H_{18}N_2O_6$ requires C, 55.90; H, 5.39; N, 8.90%).

3-(5-*Bromopentyl*)-6-*methyl*-1,3-*oxazine*-2,4(3H)-*dione* **4b** (5%), m.p. 41 °C (ethanol); *m*/*z* 278, 276 (1:1) (M^+); δ_H($CDCl_3$) 1.00–2.00 (m, 6 H, 3 × CH_2), 2.09 (s, 3 H, CH_3), 3.23 (t, *J* 6, 2 H, CH_2N), 3.57 (t, *J* 6, 2 H, CH_2Br) and 5.60 (s, 1 H, 5-H).

3,3′-*Hexamethylenebis*[6-*methyl*-1,3-*oxazine*-2,4(3H)-*dione*] **3c** (40%), m.p. 145 °C (ethanol); δ_H($CDCl_3$) 1.17–1.67 (m, 8 H, 4 × CH_2), 2.13 (s, 6 H, 2 × CH_2), 3.86 (t, *J* 7, 4 H, 2 × CH_2N) and 5.60 (s, 2 H, 2 × 5-H); ν_{max}(KBr)/cm^{-1} 1760 (C=O), 1690 (C=O) and 1650 (C=C); λ_{max}(EtOH)/nm 235 (7.3 × 10^3) (Found: C, 57.0; H, 5.9; N, 8.6. $C_{16}H_{20}N_2O_6$ requires C, 57.14; H, 5.95; N, 8.33%).

3,3′-*Oxydiethylenebis*[6-*methyl*-1,3-*oxazine*-2,4(3H)-*dione*] **11** (50%), m.p. 123 °C (ethanol); *m*/*z* 324 (M^+); δ_H($CDCl_3$) 2.19 (s, 6 H, 2 × CH_3), 3.70 (t, *J* 6, 4 H, 2 × NCH_2), 4.05 (t, *J* 6, 4 H, 2 × CH_2) and 5.74 (s, 2 H, 2 × 5-H); ν_{max}(KBr)/cm^{-1} 1745 (C=O), 1706 (C=O) and 1665 (C=C).

3,3′-(2-*Methoxy*-5-*methyl*-1,3-*phenylene*)*dimethylenebis*[6-*methyl*-1,3-*oxazine*-2,4(3H)-*dione*] **17** (40%), m.p. 250 °C (ethanol); *m*/*z* 400 (M); δ_H($CDCl_3$) 2.15 (s, 9 H, 3 × CH_3), 3.75 (s, 3 H, OCH_3), 5.03 (s, 4 H, 2 × NCH_2), 5.75 (s, 2 H, 2 × 5-H) and 6.72 (s, 2 H, ArH); ν_{max}(KBr)/cm^{-1} 1730 (C=O), 1700 (C=O) and 1680 (C=C).

Synthesis of Podands **5–10**, **12–14**, **18** and **19**.—*General procedure*. The mixture of **3a** (2.0 g, 6 mmol) and 2-aminoethanol (1.5 g, 25 mmol) was heated in an oil-bath maintained at 140–150 °C. After 2 h, the reaction mixture was cooled and triturated with ice cold water to give a white solid. This was recrystallized from ethanol to afford pure compound **5**. Similarly, compounds **3a–c**, **11** and **17** with the appropriate amino alcohols gave the corresponding podands. However, compounds **7**, **8**, **12–14**, **18** and **19** were purified through column chromatography.

3,3′-*Tetramethylenebis*[1-(2-hydroxyethyl)-6-*methylpyrimidine*-2,4(1H,3H)-*dione*] **5** (33%), m.p. 220 °C (ethanol); δ_H($CDCl_3$ + [$^2H_6$]DMSO) 1.53–1.67 (m, 4 H, 2 × CH_2), 2.26 (s, 6 H, 2 × CH_3), 3.40–4.00 (m, 12 H, 4 × NCH_2, 2 × OCH_2), 4.50–4.91 (br, 2 H, 2 × OH exchanges with D_2O) and 5.40 (s, 2 H, 2 × 5-H); ν_{max}(KBr)/cm^{-1} 3340 (OH), 1680 (C=O), 1640 (C=O) and 1610 (C=C); λ_{max}(EtOH)/nm 217 (ε 1.27 × 10^4) and 261 (ε 2.74 × 10^4) (Found: C, 54.5; H, 6.6; N, 13.7. $C_{18}H_{26}N_4O_6$ requires C, 54.8, H, 6.59; N, 14.21%).

3,3′-*Tetramethylenebis*[1-(3-*hydroxypropyl*)-6-*methylpyrimidine*-2,4(1H,3H)-*dione*] **6** (46%), m.p. 187 °C (ethanol); δ_H($CDCl_3$ + [$^2H_6$]DMSO) 1.42–2.0 (m, 8 H, 4 × CH_2), 2.26 (s, 6 H, 2 × CH_3), 2.60–3.08 (br, 2 H, 2 × OH, exchanges with D_2O), 3.52 (t, *J* 6, 4 H, 2 × CH_2), 3.80–4.0 (m, 8 H, 4 × CH_2) and 5.53 (s, 2 H, 2 × 5-H); ν_{max}(KBr)/cm^{-1} 3440(OH), 1690 (C=O), 1680 (C=O) and 1610 (C=C); λ_{max}(EtOH)/nm 217 (ε 2.23 × 10^4) and 262 (ε 1.73 × 10^4) (Found: C, 56.6; H, 7.2; N, 13.6. $C_{20}H_{30}N_4O_6$ requires C, 56.87; H, 7.11; N, 13.27%).

3,3′-*Pentamethylenebis*[1-(2-*hydroxyethyl*)-6-*methylpyrimidine*-2,4(1H,3H)-*dione*] **7** (39%), m.p. 134 °C (ethanol); *m*/*z* 408 (M^+); δ_H($CDCl_3$) 1.00–2.00 (m, 6 H, 3 × CH_2), 2.18 (s, 6 H, 2 × CH_3), 2.90–3.30 (br, 2 H, 2 × OH, exchanges with D_2O), 3.70 (m, 12 H, 4 × CH_2N, 2 × CH_2O) and 5.24 (s, 2 H, 2 × 5-H); ν_{max}($CHCl_3$)/cm^{-1} 3400 (OH), 1690 (C=O), 1660 (C=O) and 1614 (C=C); λ_{max}(EtOH)/nm 262 (ε 3.35 × 10^3) and 222 (ε 2.9 × 10^3) (Found: C, 55.7; H, 6.6; N, 13.9. $C_{19}H_{28}N_4O_6$ requires C, 55.88; H, 6.86; N, 13.72%).

3,3′-*Pentamethylenebis*[1-(3-*hydroxypropyl*)-6-*methylpyrimidine*-2,4(1H,3H)-*dione*] **8** (50%), m.p. 100 °C (ethanol); *m*/*z* 436 (M^+); δ_H($CDCl_3$) 1.33–1.90 (m, 10 H, 5 × CH_2), 2.20 (s, 6 H, 2 × CH_3), 2.00–3.20 (br, 2 H, 2 × OH, exchanges with D_2O), 3.30–4.30 (m, 12 H, 6 × CH_2), 5.43 (s, 2 H, 2 × 5-H); ν_{max}($CHCl_3$)/cm^{-1} 3400(OH), 1690 (C=O), 1650 (C=O) and 1610 (C=C); λ_{max}(EtOH)/nm 221 (ε 3.05 × 10^4) and 262 (ε 3.6 × 10^4) (Found: C, 57.6; H, 7.1; N, 13.1. $C_{21}H_{32}N_4O_6$ requires C, 57.79; H, 7.34; N, 12.84%).

3,3′-*Hexamethylenebis*[1-(2-*hydroxyethyl*)-6-*methylpyrimidine*-2,4(1H,3H)-*dione*] **9** (36%), m.p. 195 °C (ethanol); δ_H-($CDCl_3$ + [$^2H_6$]DMSO) 1.65–1.73 (m, 8 H, 4 × CH_2), 2.26 (s, 6 H, 2 × CH_3), 3.46–4.00 (m, 12 H, 6 × CH_2), 4.39–4.73 (br, 2 H, 2-OH, exchanges with D_2O) and 5.39 (s, 2 H, 2 × 5-H); ν_{max}(KBr)/cm^{-1} 3430 (OH), 1690 (C=O), 1650 (C=O) and 1610 (C=C); λ_{max}(EtOH)/nm 260 (ε 1.15 × 10^5) and 222 (ε 7.2 × 10^4) (Found: C, 56.6; H, 7.2; N, 13.0. $C_{20}H_{30}N_4O_6$ requires C, 56.87; H, 7.11; N, 13.27%).

3,3′-*Hexamethylenebis*[1-(3-*hydroxypropyl*)-6-*methylpyrimidine*-2,4(1H,3H)-dione] **10** (21%), m.p. 165 °C (ethanol); δ_H-($CDCl_3$ + [$^2H_6$]DMSO) 1.17–2.0 (m, 12 H, 6 × CH_2), 2.23 (s, 6 H, 2 × CH_3) 3.23–4.00 (m, 12 H, 6 × CH_2), 4.23–4.70 (b, 2 H, 2 × OH exchanges with D_2O) and 5.43 (s, 2 H, 2 × 5-H); ν_{max}(KBr)/cm^{-1} 3420 (OH), 1690 (C=O), 1640 (C=O) and 1620 (C=C); λ_{max}(EtOH)/nm 220 (ε 2.07 × 10^4) and 260 (ε 1.51 × 10^4) (Found: C, 58.8; H, 7.7, N, 12.7. $C_{22}H_{34}N_4O_6$ requires C, 59.19; H, 7.62; N, 12.55%).

3,3′-*Oxydiethylenebis*[1-(2-*hydroxyethyl*)-6-*methylpyrimidine*-2,4(1H,3H)-*dione*] **12** (40%), m.p. 130 °C; *m*/*z* 410 (M^+); δ_H($CDCl_3$) 2.37 (s, 6 H, 2 × CH_3), 3.74 (t, *J* 7, 4 H, 2 × CH_2), 3.93 (t, *J* 7, 8 H, 2 × NCH_2, 2 × OCH_2), 4.08 (t, *J* 7, 4 H, 2 × OCH_2), 4.88 (br, 2 H, 2 × OH, exchanges with D_2O) and 5.39 (s, 2 H, 2 × 5-H); δ_C($CDCl_3$) 20.89 (q, CH_3), 40.34 (t, NCH_2), 47.74 (t, NCH_2), 59.25 (t, OCH_2), 66.95 (t, CH_2), 100.72 (d, 5-H), 151.71 (s, C-6), 153.51 [s, C(2)=O] and 163.40 [s, C(4)=O]; ν_{max}($CHCl_3$)/cm^{-1} 3330 (OH), 1700 (C=O) and 1650 (C=O) (Found: C, 52.2; H, 6.5; N, 13.5. $C_{18}H_{26}N_4O_7$ requires C, 51.94; H, 6.34; N, 13.66%).

3,3′-*Oxydiethylenebis*[1-(3-*hydroxypropyl*)-6-*methylpyrimidine*-2,4(1H,3H)-*dione*] **13** (15%), liquid; δ_H($CDCl_3$) 1.88 (quint. *J* 6, 4H, 2 × CH_2), 2.28 (s, 2 × CH_2), 3.43 (br, 2 H, 2 × OH, exchanges with D_2O), 3.00–3.71 (m, 8 H, 4 × NCH_2), 4.00 (t, *J* 6, 4 H, 2 × OCH_2), 4.13 (t, *J*, 4 H, 2 × CH_2O) and 5.59 (s, 2 H, 2 × 5-H); δ_C($CDCl_3$) 19.67 (q, CH_3), 31.71 (t, CH_2), 40.14 (t, NCH_2), 41.86 (t, NCH_2), 58.66 (t, OCH_2), 67.07 (t, CH_2O), 101.86 (d, 5-H), 151.64 [C(2)=O], 152.87 (C-6) and 162.09 [C(4)=O]; ν_{max}($CHCl_3$)/cm^{-1} 3300 (OH), 1700 (C=O), 1648 (C=O) and 1628 (C=C).

Compound **15** (20%), m.p. 113 °C (ethanol); *m*/*z* 456 (M^+, absent) 413 (M^+ − CH_3CO) and 370 (M^+ − CH_3CO − CH_2CO); δ_H 1.88 (quint, *J* 6, 4 H, 2 × CH_2), 2.28 (s, 3 H, CH_3), 2.32 (s, 3 H, CH_3), 3.26 (br, 1 H, 1 × NH, exchanges with D_2O), 3.36–3.74 (m, 14 H, 8 × CH_2), 4.03 (t, *J* 6, 2 H, CH_2), 4.17 (t, *J* 6, 2 H, CH_2), 5.65 (s, 2 H, 2 × 5-H) and 7.35 (br, 2 H, 2 × OH, exchanges with D_2O); δ_C($CDCl_3$) 19.69 (q, CH_3), 30.42 q, CH_3), 31.70 (t, CH_2), 39.56 (t, CH_2), 40.44 (t, CH_2), 41.99 (t, CH_2), 50.98 (t, CH_2), 58.66 (t, CH_2), 67.99 (t, CH_2), 68.93 (t, CH_2),

Table 1 Extraction ($R \times 10^{-3}$, ratio of metal picrate over podand in organic layer) of podands **5–10**, **12–14**, **18** and **19**

Podand	Na^+	K^+	Tl^+	$\overset{+}{N}H_4$	$\frac{Tl^+}{Na^+}$	$\frac{Tl^+}{K^+}$	$\frac{Tl^+}{\overset{+}{N}H_4}$
5	4.09	9.38	15.61	4.36	3.81	1.66	3.58
6	3.09	5.08	4.70	4.56	1.52	0.93	1.03
7	1.54	1.39	0.95	1.94	0.62	0.68	0.49
8	4.41	4.39	4.32	4.26	0.98	0.98	1.01
9	9.00	11.01	14.00	11.79	1.56	1.27	1.19
10	8.25	11.93	11.37	7.95	1.39	0.95	1.43
12	(−)*	(−)*	(−)*	(−)*			
13	(−)*	(−)*	(−)*	(−)*			
14	20.90	28.90	23.20	22.50	1.11	1.01	1.03
18	2.40	2.70	8.40	2.56	3.50	3.05	3.25
19	5.50	5.23	6.00	3.87	1.09	1.15	1.55

(−)* Not extracted.

Table 2 Transport rates (10^{-8} mol 24 h^{-1}) of podands **5–10**, **12–14**, **18** and **19**.

Podand	Li^+	Na^+	K^+	Tl^+	$\overset{+}{N}H_4$	$\frac{Tl^+}{Li^+}$	$\frac{Tl^+}{Na^+}$	$\frac{Tl^+}{K^+}$	$\frac{Tl^+}{\overset{+}{N}H_4}$
5	7.50	14	50.50	(−)*	109.3	—	—	—	—
6	50.20	15.50	(−)*	27.10	12.4	0.54	1.75	—	2.19
7	(−)*	(−)*	(−)*	13.90	9.1	—	—	—	1.52
8	(−)*	(−)*	8.50	10.10	17.2	—	—	1.19	0.59
9	26.10	46.00	20.01	35.10	32.5	1.34	0.76	1.75	1.08
10	49.10	52.30	(−)*	50.80	34.3	1.03	0.97	—	1.48
12	11	11	16	35	43	3.18	3.18	2.18	1.23
13	(−)*	(−)*	(−)*	(−)*	(−)*	—	—	—	—
14	67	51	66	108	78	1.30	1.63	2.12	1.40
18	20.90	15.50	8.70	221	26	10.60	14.25	25.4	8.40
19	42.30	54.10	45.30	104.50	50.30	2.47	1.93	2.31	2.07

(−)* Not transported.

69.23 (t, CH_2), 102.13 (d, CH), 151.96 (s, C-6), 153.02 (s, C=O), 162.41 (s, C=O), 165.98 (s, C=O), 166,14 (s, C=O) and 203.68 (s, C=O); ν_{max}(KBr)/cm^{-1} 3400 (OH), 1700 (C=O) and 1640 (C=O) (Found: C, 52.6; H, 7.4; N, 12.4. $C_{20}H_{32}N_4O_8$ requires C, 52.85; H, 7.02; N, 12.28%).

3,3′-*Oxydiethylenebis*[1-(2-*benzylthioethyl*)-6-*methylpyrimidine*-2,4(1H,3H)-*dione*] **14** (31%), liquid; *m*/*z* 622 (M^+); δ_H($CDCl_3$) 2.09 (s, 6 H, 2 × CH_3), 2.67 (t, 4 H, 2 × SCH_2), 3.74 (m, 8 H, 2 × NCH_2, 2 × SCH_2), 3.86 (t, *J* 7, 4 H, 2 × NCH_2), 4.07 (t, *J* 7, 4 H, 2 × OCH_2), 5.48 (s, 2 H, 2 × 5-H) and 7.29 (s, 10 H, ArH); δ_C($CDCl_3$) 19.77 (q, CH_3), 29.10 (t, SCH_2), 36.39 (t, SCH_2), 39.82 (t, NCH_2), 44.76 (t, NCH_2), 53.37 (t, OCH_2), 101.48 (d, 5-H), 127.06 (d, ArCH), 128.41 (d, ArCH), 128.72 (d, ArCH), 137.81 (s, ArC), 150.80 (s, C-6), 151.65 [s, C(2)=O] and 161.75 [s, C(4)=O]; ν_{max}(KBr)/cm^{-1} 1682 (C=O) and 1640 (C=O).

3,3′-(2-*Methoxy*-5-*methyl*-1,3-*phenylene*)-2,6-*bis*[1-(2-*hydroxyethyl*)-6-*methylpyrimidine*-2,4(1H,3H)-*dione*] **18** (19%), m.p. 205 °C (ethanol); *m*/*z* 486 (M^+); δ_H($CDCl_3$ + TFA) 2.15 (s, 3 H, CH_3), 2.39 (s, 6 H, 2 × CH_3), 4.00 (s, 3 H, OCH_3), 4.19–4.80 (m, 8 H, 2 × OCH_2, 2 × NCH_2), 5.30 (s, 4 H, 2 × NCH_2), 6.06 (s, 2 H, 2 × 5-H) and 6.69 (s, 2 H, ArH); ν_{max}(KBr)/cm^{-1} 3380 (br, OH), 1730 (C=O) and 1710 (C=O).

3,3′-(2-*Methoxy*-5-*methyl*-1,3-*phenylene*)-2,6-*bis*[1-(3-*hydroxypropyl*)-6-*methylpyrimidine*-2,4(1H,3H)-*dione*] **19** (15%), m.p. 148 °C (ethanol); *m*/*z* 514 (M^+); δ_H($CDCl_3$ + TFA) 1.70–2.13 (m, 4 H, 2 × CH_2), 2.19 (s, 3 H, $ArCH_3$) 2.36 (s, 6 H, 2 × CH_3), 3.46–3.79 (m, 4 H, 2 × CH_2), 4.00 (s, 3 H, OCH_3), 4.03–4.13 (m, 4 H, 2 × OCH_2), 5.20 (s, 4 H, 2 × NCH_2), 5.66 (s, 2 H, 2 × 5-H) and 6.66 (s, 2 H, ArH); ν_{max}(KBr)/cm^{-1} 3380 (br, OH), 1750 (C=O) and 1710 (C=O).

Extraction Measurements.—An aqueous solution (2 cm^3) of metal picrate (0.02 mol dm^{-3}) (Tl^+ picrate 0.01 mol dm^{-3}) and a chloroform solution (2 cm^3) of the podand (0.01 mol dm^{-3}) were shaken in a cylindrical tube closed with a septum for 5 min and kept at 27 ± 0.1 °C for 3–4 h. An aliquot of chloroform layer (1 cm^3) was withdrawn with a syringe and diluted with acetonitrile to 10 cm^3. The UV absorption of this solution was measured against a blank solution at 374 nm.[13] Extraction of metal picrates has been calculated as the ratio (*R*)[14] of concentration of metal picrate in organic layer and concentration of the ligand in organic layer and the mean of three independent measurements which are within ± 2% error (see Table 1).

Transport Measurements.—Transport rates were determined by the method of Tsukube[15] using (i) metal picrate (0.01 mol dm^{-3}) in water (3 cm^3) in the inner phase; (ii) water (10 cm^3) in the outer phase; (iii) ligand (10 mmol dm^{-3}) in the chloroform layer (15 cm^3) with stirring (150 r.p.m.) at 27 ± 0.05 °C. The concentrations of the picrates were determined from the UV absorptions at 355 nm.[13] Each value is a mean of three experiments which are consistent within ± 10% (Table 2).

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