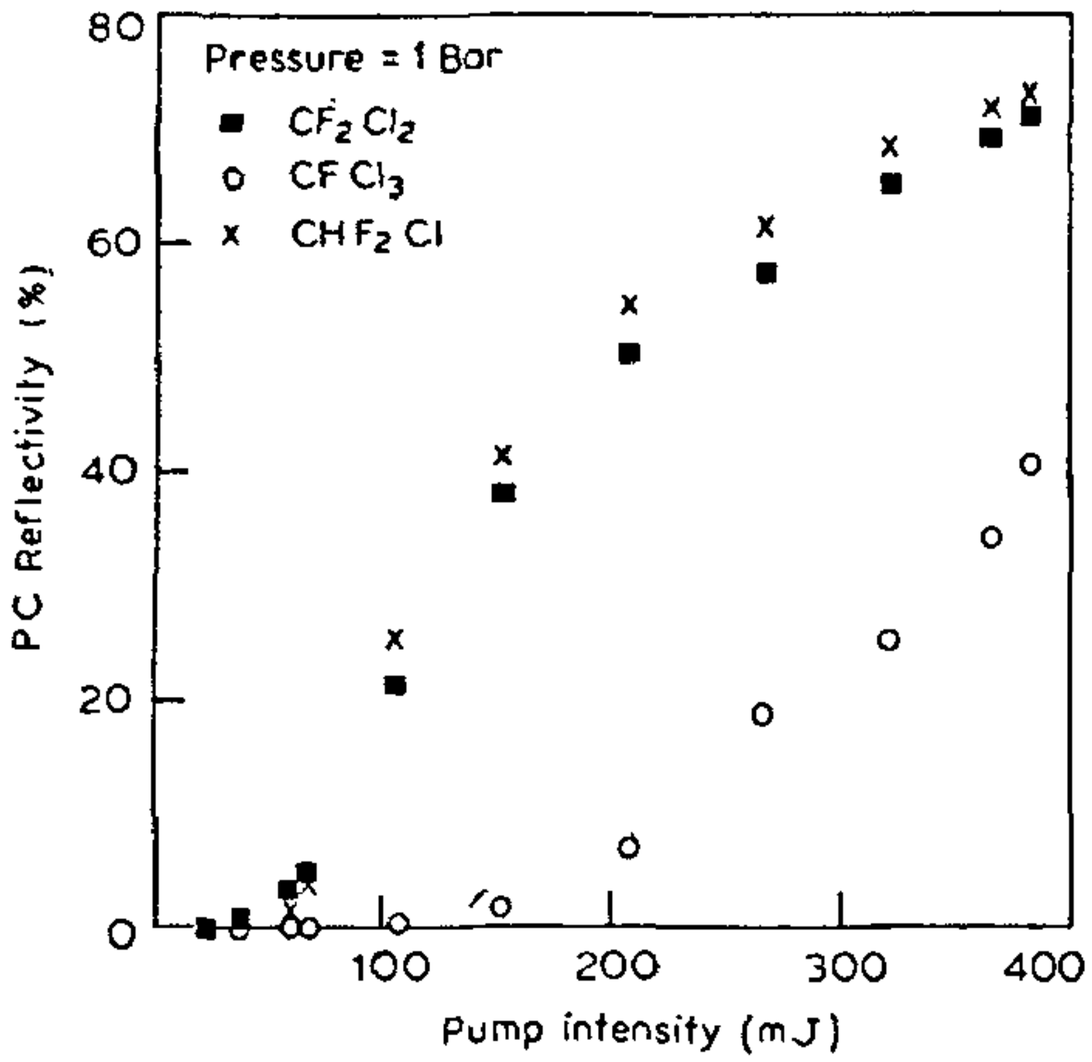

Figure 1. Intensity dependence of PC reflectivity for all gases at P = 1 bar

they were found to agree well. We have also studied the intensity dependence of OPC reflectivity for all the three gases and found that the reflectivity increases with intensity and it does not saturate as can be seen in Figure 1.

In conclusion, the three halogenated methanes studied for the first time for their phase conjugate efficiencies are highly efficient systems even at a very low pressure of the order of 1 bar. Detailed investigations on these gases are in progress.

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Crystal structure of L-phenylalanyl–glycine:trichloroacetate and its relevance to the bioactive conformation of the enkephalins

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A dipeptide L-phenylalanyl–glycine has been crystallized as a 1:1 complex with trichloroacetic acid. The crystal structure has been determined using direct methods and refined to a final *R*-index of 0.059 for 1203 reflections (with $\sin\theta/\lambda \leq 0.60$ Å^{-1} and $I \geq 3\sigma(I)$). The trans-peptide unit shows significant deviation from planarity. The peptide backbone is folded with torsion angles at glycine adopting a D-residue conformation. Relevance of the study to bioactive conformation of enkephalins is discussed.

Table 1. Crystal data for L-phenylalanyl–glycine trichloroacetic acid solvate

Molecular formula	. $C_{11}H_{14}N_2O_3$ CCl_3COOH
Molecular weight	. 385 6
Crystal system	: Monoclinic
Unit cell dimensions	: a = 11 310(2) Å
	b = 6 312(2)
	c = 11 912(1)
	β = 95 86(1)°
Volume	: 845 9(7) Å^3
Space group	· $P2_1$
Number of molecules per cell	: 2
Density calculated	· 1.514 Mgm^{-3}
Radiation used	CuK_α (λ = 1 5418 Å)
μ (CuK_α)	. 52 46 cm^{-1}
Temperature	· 25°C
Scan mode	: $\omega/2\theta$
Crystal size	: 0 20 × 0 30 × 0 70 mm
Unique reflections measured	: 1318
Number of reflections with $I \geq 3\sigma(I)$	: 1203
Absorption correction	Empirical
Maximum $\sin\theta/\lambda$	: 0 60 Å^{-1}
R	· 0 059
R_w	: 0 073

IT has been reported that enkephalins tyr–gly–gly–phe–leu (met) show enhanced activity if the second residue in the sequence, namely, glycine is substituted with a D-amino acid residue. Such a substitution would clearly force the torsion angle ϕ for this residue to assume positive ϕ values in the Ramachandran plot. The implication is that the peptide unit (involving amide and carbonyl groups) for this residue in the enkephalins presumably has to adopt a well-defined orientation

Table 2. Positional ($\times 10^4$) and equivalent thermal parameters for the non-hydrogen atoms (estimated standard deviations are in parentheses)

Atom	x	y	z	B_{eq}(Å^2)
N1	4144(3)	4360(#)	322(3)	4 1(1)
C1$^{\alpha}$	3872(5)	4570(10)	1532(4)	4 0(1)
C1′	4251(5)	2550(10)	2125(4)	4 0(1)
O1′	3948(4)	823(9)	1727(3)	5 4(1)
C1$^{\beta}$	2554(5)	4900(10)	1554(5)	5 1(2)
C1$^{\gamma}$	2209(5)	5170(10)	2734(5)	4 5(1)
C1$^{\delta_1}$	1836(6)	3460(10)	3336(6)	6 0(2)
C1$^{\delta_2}$	2254(6)	7090(20)	3250(7)	6 4(2)
C1$^{\varepsilon_1}$	1539(7)	3770(20)	4449(6)	7 6(2)
C1$^{\varepsilon_2}$	1934(9)	7380(20)	4328(7)	8 3(2)
C1$^{\xi}$	1586(7)	5710(20)	4923(6)	7 5(2)
N2	4918(4)	2726(9)	3144(4)	3 9(1)
C2$^{\alpha}$	5124(6)	920(10)	3850(4)	4 5(1)
C2′	5711(5)	−950(10)	3363(4)	3 8(1)
O21′	5529(5)	−2720(8)	3640(3)	5 3(1)
O22′	6480(3)	−422(8)	2635(3)	4 6(1)
C1*	7142(5)	4600(10)	1087(4)	3 5(1)
C2*	8445(5)	4200(10)	1523(5)	4 5(1)
O1*	6570(4)	3157(8)	626(3)	4 8(1)
O2*	6750(4)	6405(8)	1233(3)	4 7(1)
CL1	8847(2)	1544(4)	1580(2)	6 28(4)
CL2	8755(2)	5346(5)	2884(2)	8 21(5)
CL3	9306(2)	5511(5)	575(2)	7 97(5)

$B_{eq} = (4/3)[a^2 * B(1,1) + b^2 * B(2,2) + c^2 * B(3,3) + ac(\cos\beta * B(1,3)]$
Parameter kept fixed during refinement

Table 3. Bond distances (in Å) and bond angles (in deg) involving non-hydrogen atoms

Bond distances

N1–C1$^{\alpha}$	1 510(7)	C1$^{\varepsilon_2}$–C1$^{\xi}$	1 35(2)
C1$^{\alpha}$–C1′	1 498(9)	N2–C2$^{\alpha}$	1 423(8)
C1$^{\alpha}$–C1$^{\beta}$	1 509(8)	C2$^{\alpha}$–C2′	1 497(9)
C1′–O1′	1 222(8)	C2′–O21′	1 190(8)
C1′–N2	1 366(7)	C2′–O22′	1 331(7)
C1$^{\beta}$–C1$^{\gamma}$	1 507(8)	CL1–C2*	1 735(8)
C1$^{\gamma}$–C1$^{\delta_1}$	1 39(1)	CL2–C2*	1 779(6)
C1$^{\gamma}$–C1$^{\delta_2}$	1 36(1)	CL3–C2*	1 771(7)
C1$^{\delta_1}$–C1$^{\varepsilon_1}$	1 41(1)	C1*–O1*	1 216(7)
C1$^{\delta_2}$–C1$^{\varepsilon_2}$	1 38(1)	C1*–O2*	1 241(8)
C1$^{\varepsilon_1}$–C1$^{\xi}$	1 35(2)	C1*–C2*	1 533(8)

Bond angles

N1–C1$^{\alpha}$–C1′	107 4(5)	C1′–N2–C2$^{\alpha}$	120 1(5)
N1–C1$^{\alpha}$–C1$^{\beta}$	109 1(4)	N2–C2$^{\alpha}$–C2′	117 0(5)
C1′–C1$^{\alpha}$–C1$^{\beta}$	110 2(6)	C2$^{\alpha}$–C2′–O21′	122 4(5)
C1$^{\alpha}$–C1′–O1′	121 3(5)	C2$^{\alpha}$–C2′–O22′	113 6(6)
C1$^{\alpha}$–C1′–N2	117 0(6)	O21′–C2′–O22′	123 9(6)
O1′–C1′–N2	121 7(6)	O1*–C1*–O2*	124 8(5)
C1$^{\alpha}$–C1$^{\beta}$–C1$^{\gamma}$	112 5(4)	O1*–C1*–C2*	118 5(6)
C1$^{\beta}$–C1$^{\gamma}$–C1$^{\delta_1}$	121 0(7)	O2*–C1*–C2*	116 7(5)
C1$^{\beta}$–C1$^{\gamma}$–C1$^{\delta_2}$	121 4(7)	CL1–C2*–CL2	109 4(3)
C1$^{\delta_1}$–C1$^{\gamma}$–C1$^{\delta_2}$	117 6(6)	CL1–C2*–CL3	108 5(4)
C1$^{\gamma}$–C1$^{\delta_1}$–C1$^{\varepsilon_1}$	119 3(8)	CL1–C2*–C1*	114 4(5)
C1$^{\gamma}$–C1$^{\delta_2}$–C1$^{\varepsilon_2}$	122 3(9)	CL2–C2*–CL3	108 6(4)
C1$^{\delta_1}$–C1$^{\varepsilon_1}$–C1$^{\xi}$	121 1(9)	CL2–C2*–C1*	109 5(4)
C1$^{\delta_2}$–C1$^{\varepsilon_2}$–C1$^{\xi}$	120(1)	CL3–C2*–C1*	106 2(4)
C1$^{\varepsilon_1}$–C1$^{\xi}$–C1$^{\varepsilon_2}$	119 4(8)		

(corresponding to the ϕ-positive domains in the Ramachandran plot) to satisfy receptor-specific interactions. Such a stereochemistry is forbidden for L-amino acids except glycine, explaining why glycine at the 2nd position is essential for enkephalin function. Earlier crystal structure studies involving X–gly–gly and gly–gly–X peptides[1,2], where X is an aromatic residue, have indicated that glycine prefers to adopt such a conformation when preceded in the sequence by an aromatic residue. We wanted to investigate if the glycine in a dipeptide X–gly (where X is aromatic) would also show a similar preference. The crystal structure analysis of phe–gly was therefore undertaken. Various solvents were used to crystallize the peptide, and trichloroacetic acid gave the best crystals.

Crystals were found to consist of a 1:1 complex of phe–gly and trichloroacetic acid. A suitable crystal was used for data collection and the structure analysis carried out by direct methods using SHELXS86[3] and refined by full-matrix least-squares methods using SDP package[4]. The refinement converged to a final R-index of 0.059 Table 1 lists the unit cell data while the final parameters for all the non-hydrogen atoms are listed in Table 2. The bond distances and bond angles are listed in Table 3. Figure 1 shows a stereo view of the molecule.

Judged by the bond geometry the molecule has a free NH_3^+ terminus and an unionized carboxyl terminus. The chloroacetate molecule exists as a counterion The peptide unit is trans, and shows a substantial degree of non-planarity ($\omega_1 = 168.4°$). The carboxyl group is planar and makes a dihedral angle of 104.9° with the mean plane of the peptide unit. The backbone torsion angles are $\psi_1 = 132.2(5)°$, $\omega_1 = 168.4(5)$, $\phi_2 = 57.9(7)$, $\psi_{21} = 32.5(7)$ and $\psi_{22} = -150.0(6)$. The structure confirms the expectation of a D-residue conformation for glycine, a common feature observed in peptides where two or more contiguous glycyl residues are preceded or followed by an aromatic residue[1,2]. The (ϕ, ψ) values at glycine (57.9°, 32.5°) are characteristic of a left-handed 3_{10}-helix. The side chain conformation of the phenylalanyl residue is described by (χ_1, χ_2) = (−178.8, 85.7°), and has been observed elsewhere[2,5]. It is also one of the energetically favourable conformations[6,7].

Figure 2 shows the packing of the molecules viewed down b-axis. Packing is influenced by the well-ordered solvent molecule and the tight packing in the crystal is exemplified by a high value for the calculated crystal density (1.514 Mgm^{-3}). All available protons are involved in the formation of hydrogen bonds as listed in Table 4. The amino terminal protons bridge the acetate part of successive translationally related solvent molecules through hydrogen bonds, thus forming an infinite chain

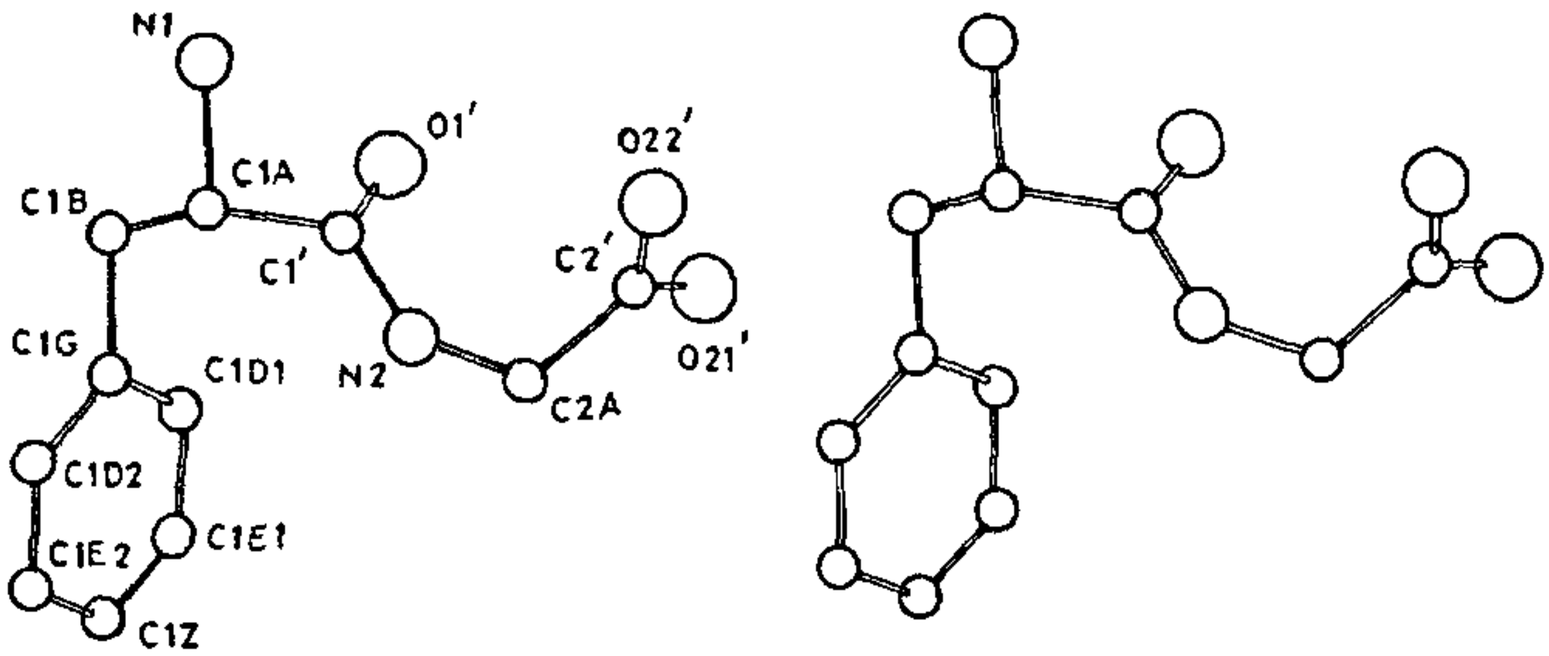

Figure 1. Stereo view of the molecule of L-phenylalanyl–glycine

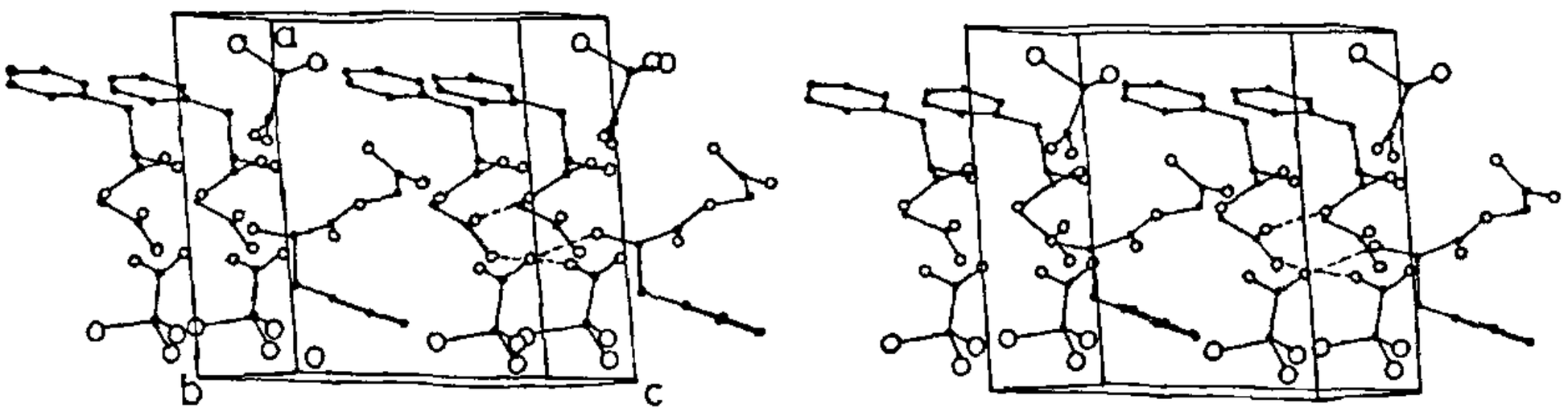

Figure 2. Packing of the molecules viewed down the b-axis

Table 4. Proposed scheme of hydrogen bonds in the structure of L-phenylalanyl–glycine trichloroacetic acid solvate

D–H...A	D–H (Å)	H...A (Å)	D ..A (Å)	Angle at H	Location of acceptor
N1–H1...O1*	0 98(7)	1 94(7)	2 834(6)	151(6)°	x, y, z
N1–H2.. O1*	0 98(8)	1 77(9)	2.737(5)	168(5)°	$1-x, y+1/2, -z$
N1–H3...O2*	0 95(7)	1 85(7)	2 747(5)	157(6)°	$1-x, y-1/2, -z$
N2–H12...O21′	0 98(6)	2 06(6)	3 001(8)	160(4)°	$x, 1+y, z$
O22′...O2*	H atom not located		2 646(6)		$x, y-1, z$

along the *b*-axis. The amide hydrogen of each peptide molecule forms an inter-backbone hydrogen bond with the terminal carboxyl atom of a translationally related neighbour (along the *b*-axis).

Considerable interest centres around identifying the structural and conformational features of the enkephalins, the endogeneous brain peptides with morphine-like activity. Crystallographic studies on leu-enkephalin[8] have shown that the molecules adopt a β-turn structure centred around gly^2–gly^3, while spectroscopic studies[9] have been interpreted in terms of a gly^3–phe^4 β-turn. The gly–gly segment can provide considerable conformational flexibility to the backbone, and this led to the suggestion that the enkephalins may possess highly flexible conformation[10], as was also implied by the observation of extended conformations for the peptide backbone in the crystallographic studies on leu-enkephalin by Karle *et al.*[11]. However, studies with stereochemically constrained enkephalin analogues in which one or the other of the glycines is substituted with the Aib (α-aminoisobutyric acid) residue show enhanced biological activity[12]. Since Aib residues generally constrain the backbone torsion angles to $\phi, \psi = \pm 60°, \pm 30°$, a β-turn structure was implicated[12] as the bioactive conformation for the analogues. However, β-turn conformation may not be an essential requirement[12] since the *N*-methyl phe^4 analogue (where the $4 \rightarrow 1$ hydrogen bond of a β-turn cannot occur) is also biologically active[13]. These reports coupled with the observations that: (i) Aib analogues show enhanced biological activity; and (ii) substitution of gly^2 with D-residues enhances biological activity; imply that the backbone can still adopt a

pseudo β-turn conformation with positive ϕ_2 and ϕ_3 values, centred around 60–90°, but without the formation of the 4 → 1 hydrogen bond. It is also possible to reconcile the observation by Karle *et al.*[11] about the bioactive conformation being extended, since both ϕ_2 and ϕ_3 are positive for two of the four conformers in the crystal structure of leu-enkephalin studied by them. In other words, biological activity presumably requires that spatial orientation of the second peptide bond (between gly^2 and gly^3) be such as to make ϕ_2 and ϕ_3 positive. Such an orientation must be clearly a dominant, sequence-dependent feature induced by the presence of the aromatic residues flanking the gly^2–gly^3 pair, as revealed by the present study as well as by the earlier crystallographic studies on several small peptides such as tyr–gly–gly[14], trp–gly–gly[15], phe–gly–gly^2, gly–gly–phe·HCl[1], tyr–gly–gly–phe[5], and t-Boc–gly–gly–phe–OEt[16]. The specific bioactive conformation thus appears to be dictated by, along with other structural and conformational features, the need for involving either the amino or carbonyl function associated with the second peptide bond in its interaction with the receptor. Replacement of the gly^2–gly^3 peptide bond with an olefinic bond may throw some light on this matter.

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The kinematic viscosities of ethylene glycol and castor oil

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Kinematic viscosities of ethylene glycol and castor oil have been measured in the temperature range 10–50°C using Ubbelohde viscometers. Empirical correlations give reasonably accurate representation of the data. These data should be useful to those who would like to use these liquids as calibrating fluids for high viscosity measurements

A problem faced while measuring relative viscosity is that suitable calibrating fluids are not available in India. For low viscosity fluids, distilled water and some of the organic solvents can be used. But for fluids of high viscosity, data on suitable calibrating liquids are not easily available. We experienced this difficulty during our recent measurements on glycerol–water mixtures as the viscosity of glycerol is a few orders of magnitude greater than that of water. This note documents our data on ethylene glycol and castor oil that we feel would be useful for intermediate and high range of viscosities of Newtonian fluids.

The kinematic viscosity measurements reported here were made using a series of Ubbelohde, suspended level viscometers[1, 2]. This method has an advantage that it is the kinematic viscosity, the quantity of interest to hydrodynamicists, rather than the dynamic viscosity that is measured. In principle the measurement, based on Poiseuille flow through a capillary, is very simple; in practice, great care has to be taken to obtain reliable data. Details of our set-up and procedures were documented earlier[3] and are not repeated here. However, we should emphasize that a thermostat was employed to carefully control the temperature (variations during measurements were less than ± 0.01°C) and drainage times were in excess of 200 seconds to make kinetic energy corrections superfluous. The ethylene glycol used in these measurements was stated by the manufacturer to have a boiling point range of 194–199°C; both ethylene glycol and castor oil used were manufactured by Loba Chemie Pvt. Ltd.

Table 1 lists the measured values for kinematic viscosities of ethylene glycol and castor oil as functions of temperature. Note that while measurements were made nominally at temperatures ranging from 10°C to 50°C in steps of 5°C, the actual temperature at the capillaries during measurements are recorded in the table. The measurements range over 2½ orders of magnitude in kinematic viscosity. The uncertainty in the ethylene glycol data was measured to be less than ± 1% while for the castor oil data the corresponding figure was ± 4%. We believe these are conservative estimates.