Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Thermal Conductivity of Ethylene Glycol and Propylene Glycol Nanofluids with Boron Nitride Nano-barbs

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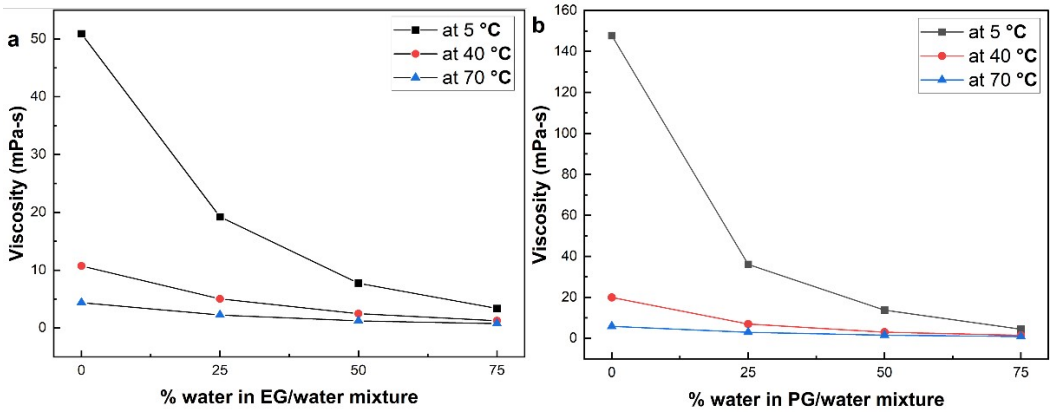
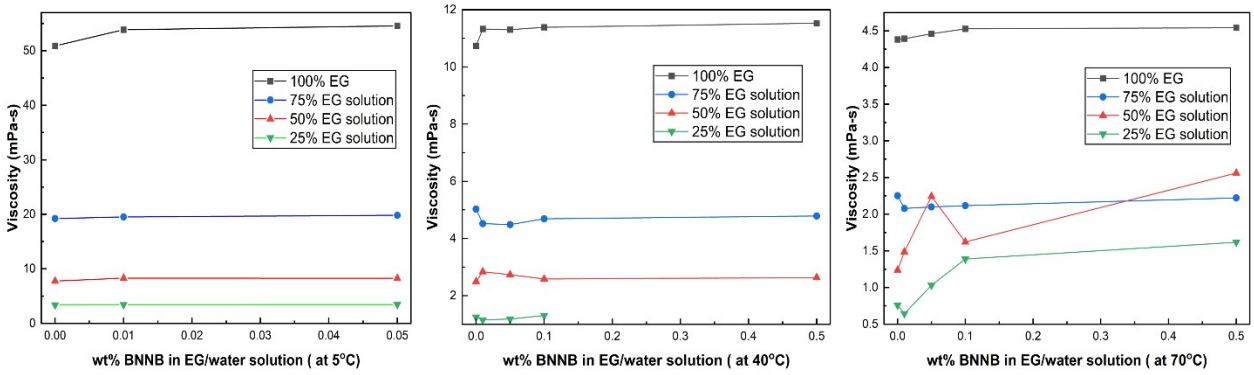
SI 1: Dilution chart for the 10wt% BNNB ethylene- and propylene-glycol stock solution.

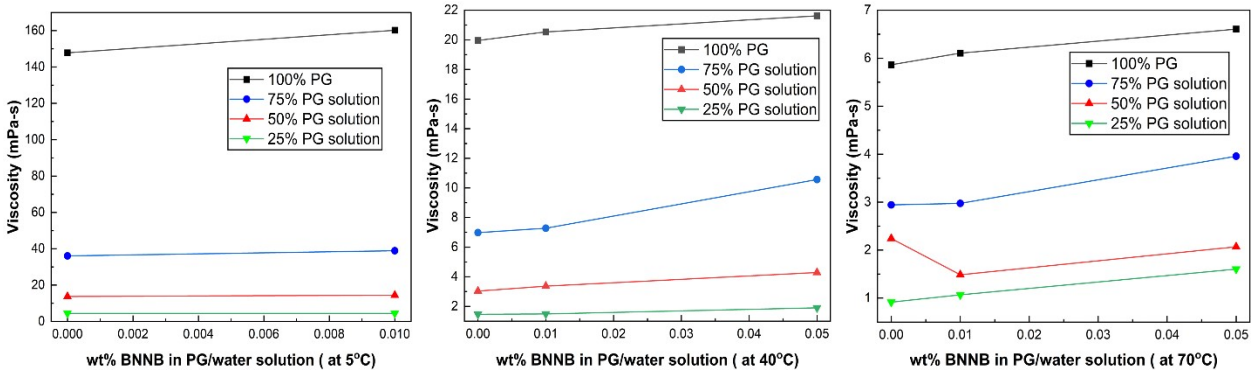
		concentration	Sample creation	NB stock	Previous sample	Ethylene glycol	DI water	75:25 EG:DI	50:50 EG:DI	25:75 EG:DI
	Stock solution in EG	10								
EG dispersion	EG1	5		5		5				
	EG2	1			2	8				
	EG3	0.5			5	5				
	EG4	0.1			2	8				
	EG5	0.05			5	5				
	EG6	0.01			2	8				
	EG0	0			0	10				
50:50 EG: water dispersion	50EG1	5		5			5			
	50EG2	1			2				8	
	50EG3	0.5			5				5	
	50EG4	0.1			2				8	
	50EG5	0.05			5				5	
	50EG6	0.01			2				8	
	50EG0	0			0				10	
25:75 EG: water dispersion	25EG1	2.5		1			3			
	25EG2	1		1			3			6
	25EG3	0.5			5					5
	25EG4	0.1			2					8
	25EG5	0.05			5					5
	25EG6	0.01			2					8
	25EG0	0			0					10
75:25 EG: water dispersion	75EG1	5		5		2.5	2.5			
	75EG2	1			2			8		
	75EG3	0.5			5			5		
	75EG4	0.1			2			8		
	75EG5	0.05			5			5		
	75EG6	0.01			2			8		
	75EG0	0			0			10		



SI 2: Thermal conductivity measurement of a. ethylene glycol/ water mixture b. propylene glycol/ water mixture



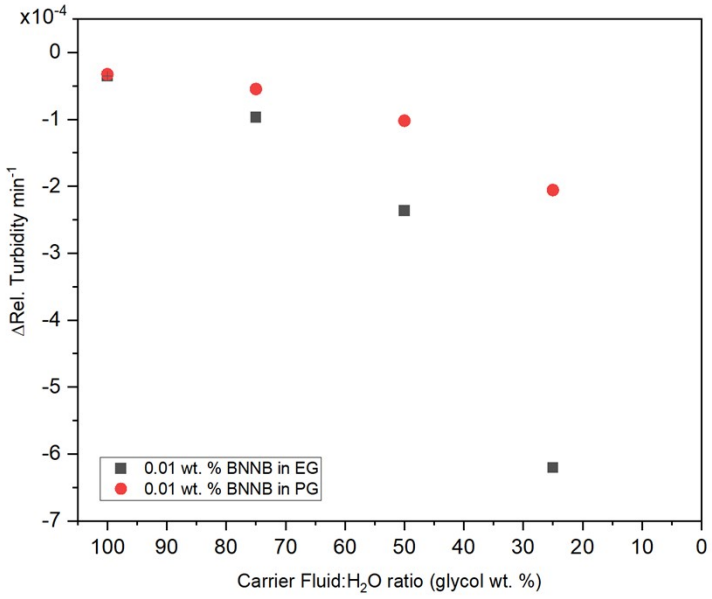
SI 3: Viscosity measurements of ethylene glycol/water mixture boron nitride nano-barbs nanofluids at 5, 40 and 70 °C



SI 4: Viscosity measurements of propylene glycol/water mixture boron nitride nano-barbs nanofluids at 5, 40 and 70 °C

SI 5: Slope values of the relative turbidity data against time at 475 nm of ethylene glycol/water mixture and propylene glycol/water mixture BNNB nanofluids

	Slope	**R square**
Ethylene Glycol - Water		
0.01 wt% 100% EG	-3.5458E-5 ± 1.21017E-7	0.99892
0.01 wt% 75% EG	-9.6823E-5 ± 6.65092E-7	0.99563
0.01 wt% 50% EG	-2.3635E-4 ± 1.89974E-6	0.99403
0.01 wt% 25% EG	-6.203E-4 ± 2.68798E-6	0.99826
Propylene Glycol - Water		
0.01 wt% 100% PG	-3.28761E-5 ± 1.11497E-6	0.90337
0.01 wt% 75% PG	-5.49009E-5 ± 1.30176E-6	0.95031
0.01 wt% 50% PG	-1.02154E-4 ± 2.11978E-6	0.9615
0.01 wt% 25% PG	-2.05853E-4 ± 3.19707E-6	0.97806



SI 6: Experimental value for the thermal conductivity of ethylene and propylene glycol – water BNNB nanofluids.

% Water in EG/water soltuion	0 °C	*Standard Deviation (±)*	40 °C	*Standard Deviation (±)*	**% Water in PG/water soltuion**	0 °C	*Standard Deviation (±)*	40 °C	*Standard Deviation (±)*
0	0.254	*0.0079*	0.25825	*0.01287*	**0**	0.21075	*0.07298*	0.21054	*0.01323*
25	0.303	*0.0165*	0.32021	*0.02371*	**25**	0.28146	*0.05264*	0.28207	*0.01269*
50	0.373	*0.02872*	0.38525	*0.02691*	**50**	0.37	*0.0364*	0.38226	*0.02276*
75	0.449	*0.0131*	0.49202	*0.02367*	**75**	0.442	*0.0352*	0.48268	*0.02684*

wt% BNNB in EG/water solution (at 40 °C)	Ethylene Glycol (k (W m^{-1} K^{-1}))	*Standard Deviation (±)*	75% EG (k (W m^{-1} K^{-1}))	*Standard Deviation (±)*	50% EG (k (W m^{-1} K^{-1}))	*Standard Deviation (±)*		25% EG (k (W m^{-1} K^{-1}))	*Standard Deviation (±)*
10	0.37382	*0.02353*							
5	0.28963	*0.01853*	0.38716	*0.0161*	0.4322	*0.01466*	**2.5**	0.52537	*0.04516*
1	0.26932	*0.01048*	0.34081	*0.01133*	0.40953	*0.01789*	**1**	0.51652	*0.03043*
0.5	0.26748	*0.01385*	0.33094	*0.01867*	0.39872	*0.01346*	**0.5**	0.5136	*0.05356*
0.1	0.26366	*0.0129*	0.32872	*0.02722*	0.39773	*0.01368*	**0.1**	0.50871	*0.04417*
0.05	0.26197	*0.01297*	0.32524	*0.01902*	0.39469	*0.01941*	**0.05**	0.50445	*0.0473*
0.01	0.26097	*0.01419*	0.32431	*0.0304*	0.39102	*0.02058*	**0.01**	0.50184	*0.02629*
0	0.25825	*0.01287*	0.32021	*0.02371*	0.38525	*0.02691*	**0**	0.49202	*0.02367*

wt% BNNB in PG/water solution (at 40 °C)	Propylene Glycol (k (W m^{-1} K^{-1}))	*Standard Deviation (±)*	75% PG (k (W m^{-1} K^{-1}))	*Standard Deviation (±)*	50% PG (k (W m^{-1} K^{-1}))	*Standard Deviation (±)*		25% PG (k (W m^{-1} K^{-1}))	*Standard Deviation (±)*
10	0.29101	*0.00741*							
5	0.25325	*0.01125*	0.33498	*0.02127*	0.42046	*0.0238*	**2.5**	0.51888	*0.04298*
1	0.2227	*0.01512*	0.29964	*0.02052*	0.39965	*0.03524*	**1**	0.51118	*0.0293*
0.5	0.2217	*0.00968*	0.29484	*0.0154*	0.3928	*0.02378*	**0.5**	0.50911	*0.04161*
0.1	0.21267	*0.01041*	0.2903	*0.01419*	0.38978	*0.04054*	**0.1**	0.50158	*0.01477*
0.05	0.21328	*0.01677*	0.28745	*0.01881*	0.38871	*0.02893*	**0.05**	0.49601	*0.04416*
0.01	0.21167	*0.0171*	0.28558	*0.02026*	0.38638	*0.03683*	**0.01**	0.48766	*0.0284*
0	0.21054	*0.01323*	0.28207	*0.01269*	0.38226	*0.02276*	**0**	0.48268	*0.02684*

Hansen Solubility Parameter Discussion

Hansen Solubility Parameters (HSP) are a set of three values that represent the relative energy contributions from dispersion forces (δD), polar forces (δP), and hydrogen bonding (δH) in a solvent or mixture. These parameters can help predict the solubility of various substances in a given solvent or solvent mixture. When mixing two solvents, the HSP values of the mixture can be calculated as a weighted average of the individual solvents' HSP values based on their respective volume fractions.

First, consider the HSP values of pure water, ethylene glycol (EG), and propylene glycol (PG):

	Hansen solubility parameters ($MPa^{0.5}$)		
	δD	δP	δH
Ethylene glycol [37, 38]	17	11	26
Propylene glycol [37]	16.8	9.4	23.3
Water	15.1	20.4	42.3

1. Water: δD = 15.1 MPa^0.5, δP = 20.4 MPa^0.5, δH = 42.3 MPa^0.5
2. Ethylene Glycol: δD = 17.0 MPa^0.5, δP = 11.0 MPa^0.5, δH = 26.0 MPa^0.5
3. Propylene Glycol: δD = 16.8 MPa^0.5, δP = 9.4 MPa^0.5, δH = 23.3 MPa^0.5

Then we recalculate the HSP values for each mixture of water and ethylene glycol or propylene glycol at the specified concentrations:

25% water in ethylene glycol:
δD = (0.25 × 15.1) + (0.75 × 17.0) = 16.525 MPa^0.5 δP = (0.25 × 20.4) + (0.75 × 11.0) = 13.35 MPa^0.5 δH = (0.25 × 42.3) + (0.75 × 26.0) = 30.075 MPa^0.5

50% water in ethylene glycol:
δD = (0.5 × 15.1) + (0.5 × 17.0) = 16.05 MPa^0.5 δP = (0.5 × 20.4) + (0.5 × 11.0) = 15.7 MPa^0.5 δH = (0.5 × 42.3) + (0.5 × 26.0) = 34.15 MPa^0.5

75% water in ethylene glycol:
δD = (0.75 × 15.1) + (0.25 × 17.0) = 15.575 MPa^0.5 δP = (0.75 × 20.4) + (0.25 × 11.0) = 18.05 MPa^0.5 δH = (0.75 × 42.3) + (0.25 × 26.0) = 38.225 MPa^0.5

25% water in propylene glycol:
$\delta D = (0.25 \times 15.1) + (0.75 \times 16.8) = 16.375$ MPa^0.5 $\delta P = (0.25 \times 20.4) + (0.75 \times 9.4) = 12.15$ MPa^0.5 $\delta H = (0.25 \times 42.3) + (0.75 \times 23.3) = 28.05$ MPa^0.5

50% water in propylene glycol:
$\delta D = (0.5 \times 15.1) + (0.5 \times 16.8) = 15.95$ MPa^0.5 $\delta P = (0.5 \times 20.4) + (0.5 \times 9.4) = 14.9$ MPa^0.5 $\delta H = (0.5 \times 42.3) + (0.5 \times 23.3) = 32.8$ MPa^0.5

75% water in propylene glycol:
$\delta D = (0.75 \times 15.1) + (0.25 \times 16.8) = 15.525$ MPa^0.5 $\delta P = (0.75 \times 20.4) + (0.25 \times 9.4) = 17.65$ MPa^0.5 $\delta H = (0.75 \times 42.3) + (0.25 \times 23.3) = 37.55$ MPa^0.5