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Some Physical Properties of Cubic System of Solid Solutions

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ABSTRACT

The norm of elastic constant tensor and the norms of the irreducible parts of the elastic constants of different types of solid solutions are calculated. The relation of the scalar parts norm and the other parts norms and the anisotropy of these solid solutions are characterized. The norm ratios are used to study anisotropy of these solid solutions.

Keywords : Solid Solutions, Isotropy, Norm, Anisotropy, Elastic Constants.

I. INTRODUCTION

The decomposition procedure and the decomposition of elastic constant tensor (Elastic constant tensor can be decomposed into two scalar parts, two deviator parts and one nonor part) is given in [1-4], also the definition of norm concept and the norm ratios and the relationship between the anisotropy and the norm ratios are given in [1-6]. As the ratio Ns /N (Norm of the scalar part of the elastic constant tensor/Norm of the elastic constant tensor) becomes close to one the material becomes more isotropic, and as the sum of the ratios Nd /N (Norm of the deviator part of the elastic constant tensor/Norm of the elastic constant tensor) and Nn /N (Norm of the nonor part of the elastic constant tensor/Norm of the elastic constant tensor) becomes close to one the material becomes more anisotropic as explained in [1-6]. We planned to study the isotropy of different types of solid solutions because when the properties of a material vary with different crystallographic orientations, the material is said to be anisotropic. Alternately, when the properties of a material are the same in all directions, the material is said to be isotropic.

II. DATA and CALCULATIONS

Table 1. Elastic Constants (GPa), [7]

Solid Solution[1,2]	C_{11}	C_{44}	C_{12}
KCl - RbCl			
mole % RbCl			
0	40.0	6.3	6.9
25	38.4	5.7	6.8
50	37.6	5.4	6.6
75	36.8	5.0	6.4
100	36.4	4.8	6.3
KCl - NaCl			

mole % KCl			
0	49.1	12.7	14.0
3.8	47.7	12.2	12.9
5.6	47.3	11.4	12.6
82.4	38.6	6.10	6.44
90.0	38.9	6.14	6.47
100	41.0	6.25	7.08
KI - KBr			
mole % KI			
0	34.68	5.07	5.22
23.5	32.30	4.67	4.86
61.5	29.43	4.09	4.33
78	28.55	3.87	4.13
100	27.60	3.71	3.98
$K_{0.5}Rb_{0.5}I$	30.4	5.03	1.23
AgBr - AgCl			
mole % AgCl			
0	56.5	7.3	32.7
19.5	56.1	7.0	32.7
39.1	55.9	6.8	32.7
56.5	56.0	6.6	33.0
78.7	57.4	6.4	34.2
NaBr - KBr			
mole % KBr			
0	41.1	10.0	9.9
7	39.7	9.5	9.7
15	38.0	9.0	9.0
82	33.0	5.5	6.0
92	33.7	5.25	5.7
97	34.2	5.1	5.4
100	34.6	5.0	5.2
NaCl - NaBr			
mole % NaBr			
0	47.63	12.70	13.19
11.5	46.46	12.38	12.88
26	45.07	11.94	12.77
50.5	43.02	11.31	12.30
63	41.96	10.94	12.00
78.5	41.13	10.52	12.01
100	39.36	9.94	11.36
$Tb_{0.3}Dy_{0.7}Fe_2$	117	38.4	40
$ZrO_2 – Y_2O_3$			
mole % Y_2O_3			
8	394	56	91
10.3	403	58	83
12	449	62	55

By using and the decomposition of the elastic constant tensor, the norms and the norm ratios are calculated as shown in table 2.

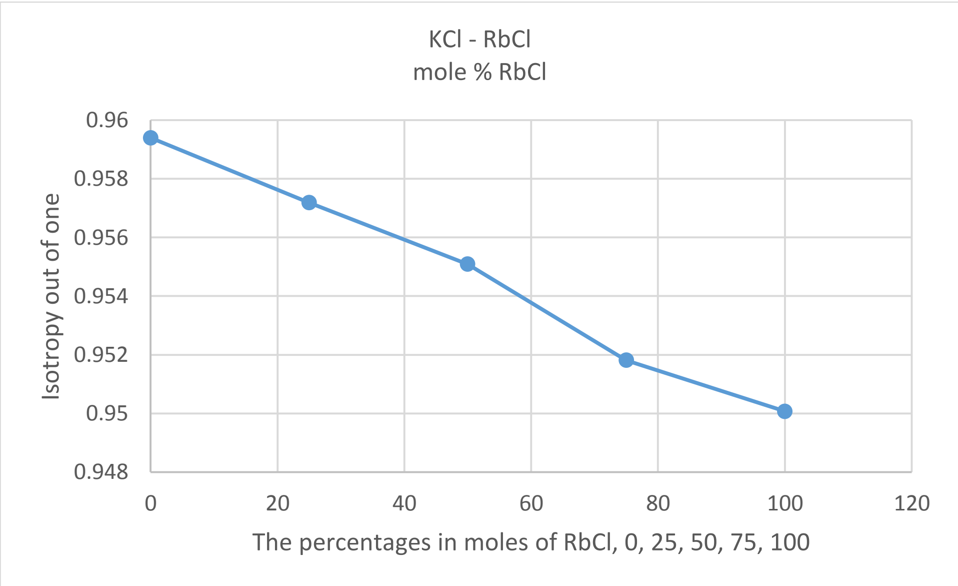
Table 2. the norms and norm ratios

Solid Solution[1,2]	N_s	N_d	N_n	N	$\frac{N_s}{N}$	$\frac{N_d}{N}$	$\frac{N_n}{N}$
KCl - RbCl mole % RbCl							
0	63.908	0	18.78856	66.61239	0.959397	0	0.282058
25	61.217	0	18.51361	63.95543	0.957185	0	0.289477
50	59.673	0	18.51361	62.47914	0.95509	0	0.296317
75	58.026	0	18.69691	60.96429	0.951811	0	0.306686
100	57.204	0	18.78856	60.21063	0.950067	0	0.312047
NaCl - KCl mole % KCl							
0	91.116	0	8.890197	91.54819	0.995274	0	0.097109
3.8	87.438	0	9.531757	87.95571	0.994111	0	0.10837
5.6	85.703	0	10.90653	86.3943	0.992	0	0.126241
82.4	61.405	0	18.29364	64.07169	0.958373	0	0.285518
90.0	61.847	0	18.46778	64.54582	0.958194	0	0.286119
100	65.294	0	19.63175	68.181	0.95765	0	0.287936
KBr - KI mole % KI							
0	53.980	0	17.70707	56.80964	0.950183	0	0.311691
23.5	50.216	0	16.58892	52.88514	0.949529	0	0.313678
61.5	45.446	0	15.50744	48.01871	0.946417	0	0.322946
78	43.888	0	15.28747	46.47444	0.94435	0	0.328944
100	**42.377**	**0**	**14.84755**	**44.90313**	**0.943751**	**0**	**0.330657**
$K_{0.5}Rb_{0.5}I$	**44.065**	**0**	**17.5146**	**47.41812**	**0.929284**	**0**	**0.369365**
$Tb_{0.3}Dy_{0.7}Fe_2$	**234.655**	**0**	**0.183303**	**234.6551**	**1**	**0**	**0.000781**
AgBr - AgCl mole % AgCl							
0	**125.613**	**0**	**8.431939**	**125.8954**	**0.997755**	**0**	**0.066976**
19.5	125.019	0	8.615242	125.3151	0.997634	0	0.068749
39.1	124.700	0	8.798545	125.0101	0.99752	0	0.070383
56.5	125.260	0	8.981848	125.5814	0.997439	0	0.071522
78.7	128.906	0	9.531757	129.2575	0.997277	0	0.073742
NaBr - KBr mole % KBr							
0	73.1902	0	10.26497	73.90652	0.990308	0	0.138891

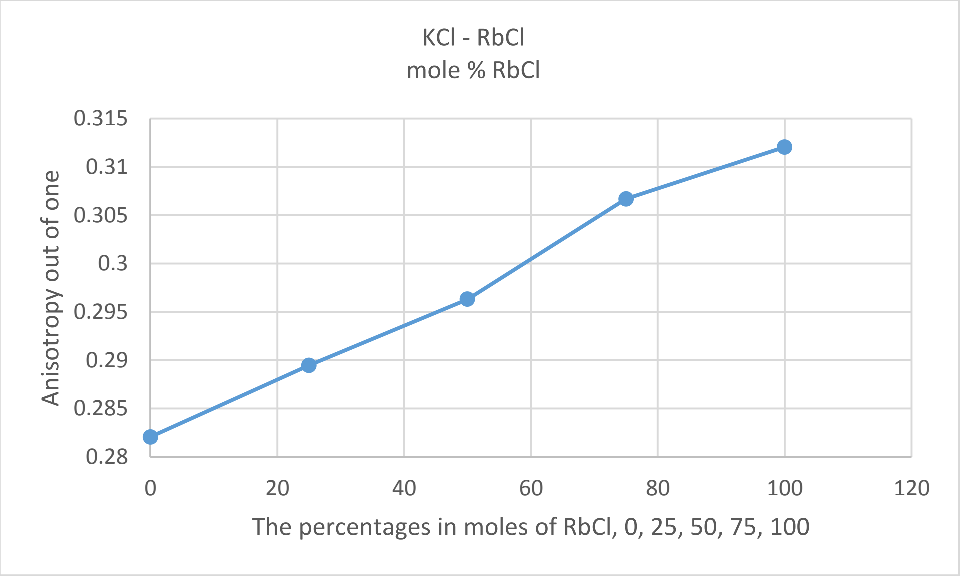
7	70.7008	0	10.08167	71.41596	0.989986	0	0.141168
15	67.2	0	10.08167	67.95204	0.988933	0	0.148364
82	53.4564	0	14.66424	55.43131	0.964373	0	0.264548
92	53.6302	0	16.03901	55.97721	0.958072	0	0.286528
97	53.6723	0	17.04718	56.3145	0.953081	0	0.302714
100	53.7810	0	17.78039	56.64398	0.949457	0	0.313897
NaCl - NaBr mole % NaBr							
0	88.2767	0	8.285297	88.6647	0.995624	0	0.093445
11.5	86.1180	0	8.083664	86.49656	0.995623	0	0.093456
26	83.8303	0	7.717057	84.18475	0.99579	0	0.091668
50.5	80.0718	0	7.423773	80.41524	0.99573	0	0.092318
63	78.0058	0	7.405442	78.35654	0.995524	0	0.09451
78.5	76.5809	0	7.405442	76.9381	0.995357	0	0.096252
100	72.972	0	7.442103	73.35052	0.99484	0	0.101459
$ZrO_2 – Y_2O_3$ mole % Y_2O_3							
8	655.276	0	175.0544	678.2552	0.966119	0	0.258095
10.3	656.610	0	186.9691	682.711	0.961769	0	0.273863
12	**678.599**	**0**	**247.4591**	**722.3109**	**0.939484**	**0**	**0.342594**

1. A solid solution is a solid solvent or mixture of two crystalline solids that coexist as a new crystalline solid or crystal lattice [8].

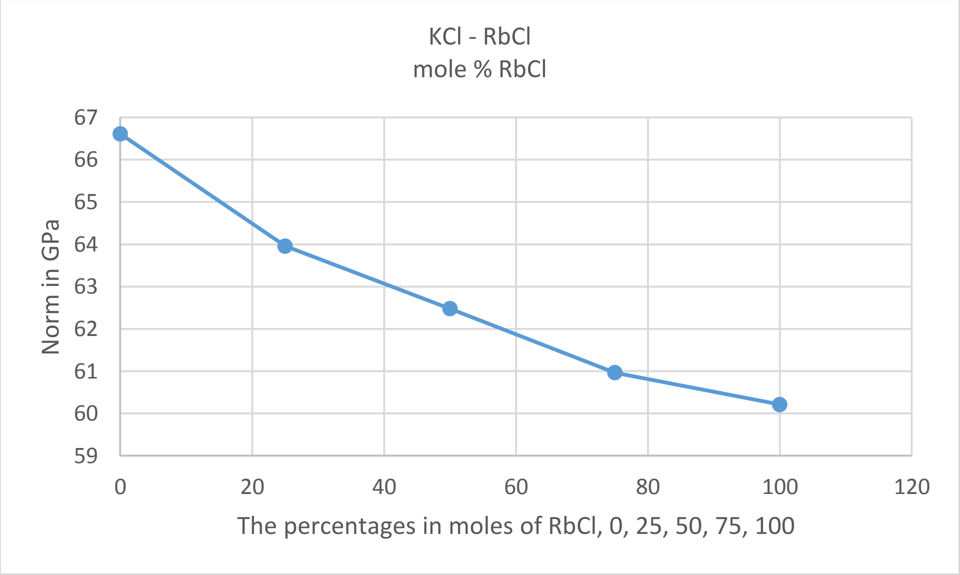
2. When two metals are mixed together they form an alloy if one metal is soluble in the other one in solid state. Therefore, an alloy is a solid solution of two or more metals. Primarily there are two types of solid solutions - Substitutional – Solute atoms occupy the regular lattice sites of the parent metal (solvent). Substitutional solid solutions can be random (Cu-Ni) or ordered (Cu-Au). Interstitial – Solute atoms occupy the interstitial positions (Steel – C solute atoms in Fe) [9].



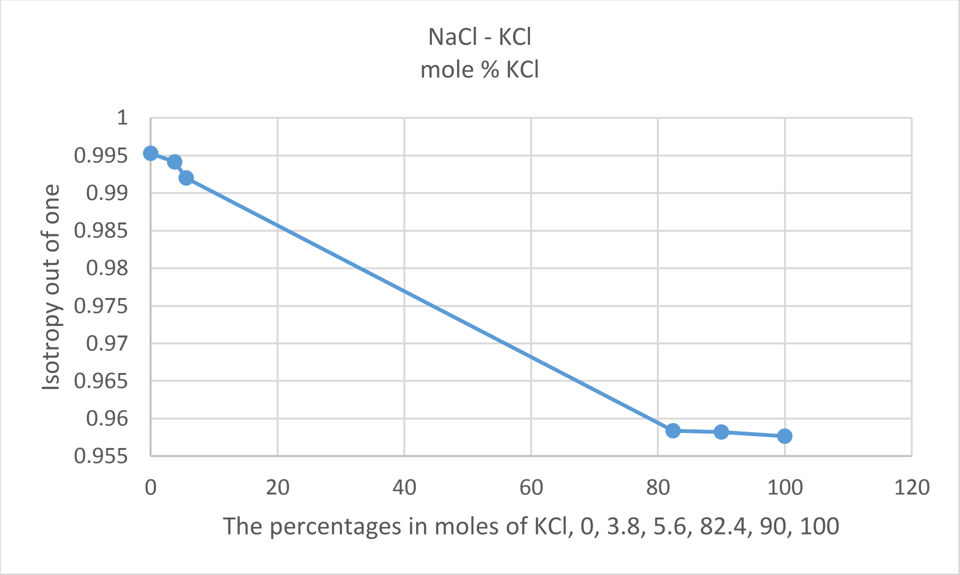
Graph 1. Isotropy Degree.



Graph 2. Anisotropy Degree.



Graph 3. Elastically Srong.



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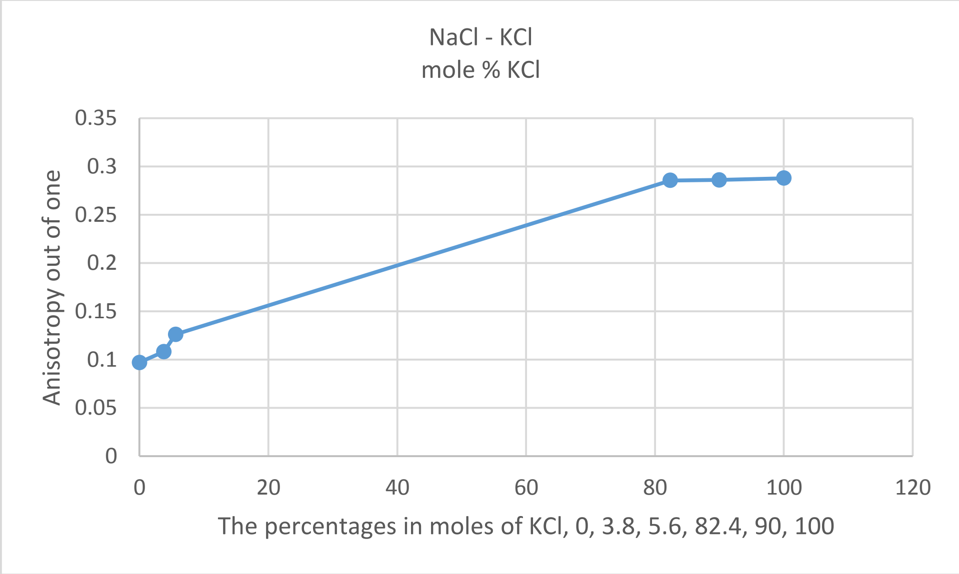
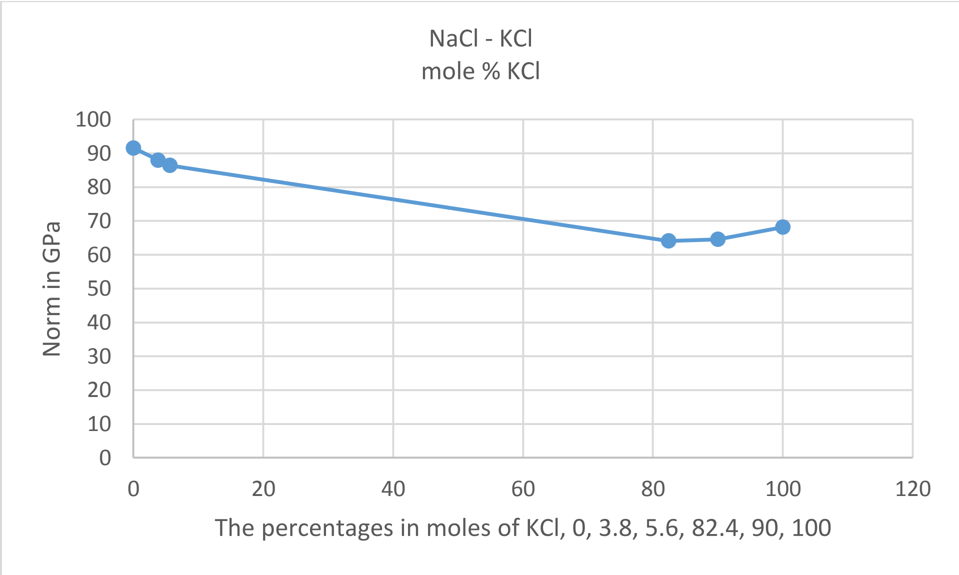
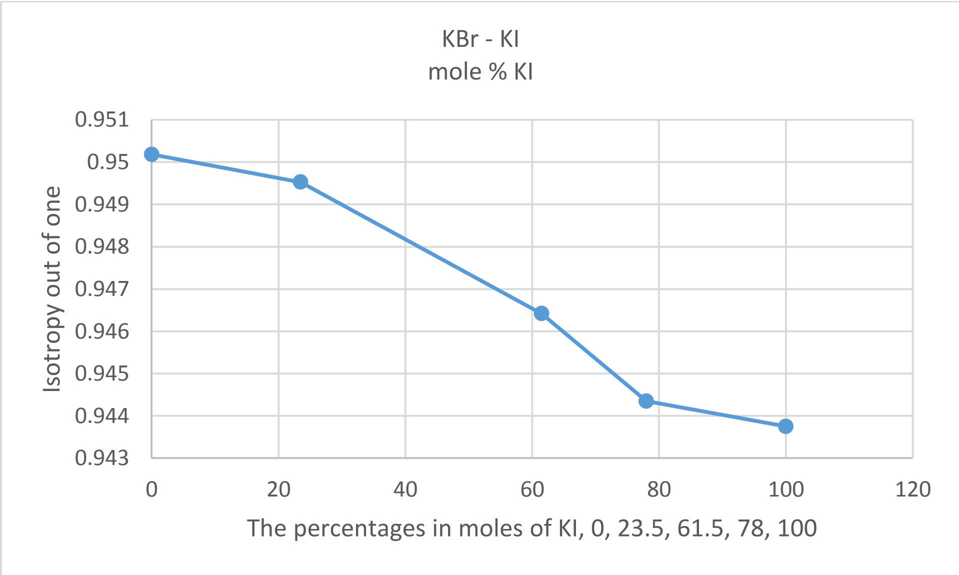


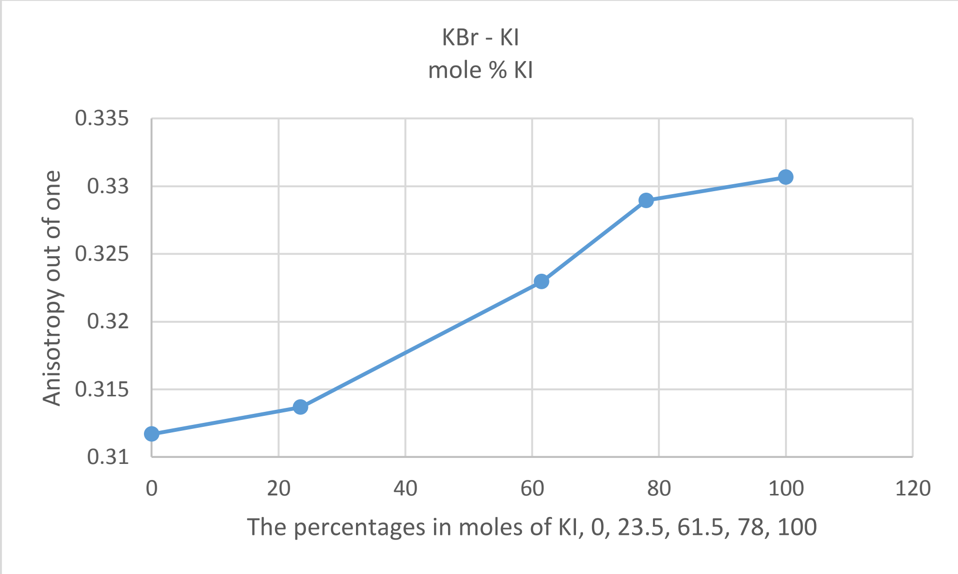
Graph 5. Anisotropy Degree.



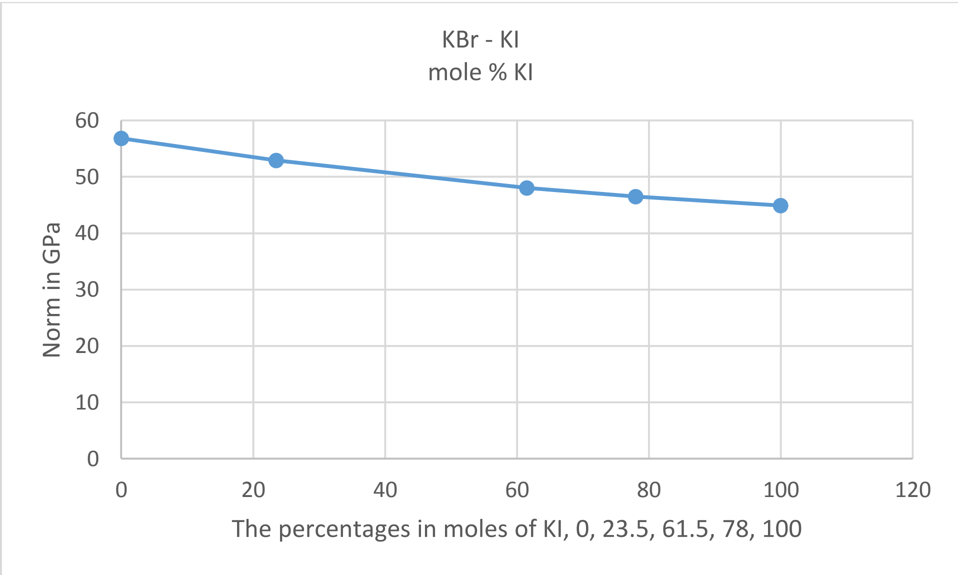
Graph 6. Elastically Srong.



Graph 7. Isotropy Degree.



Graph 8. Anisotropy Degree.



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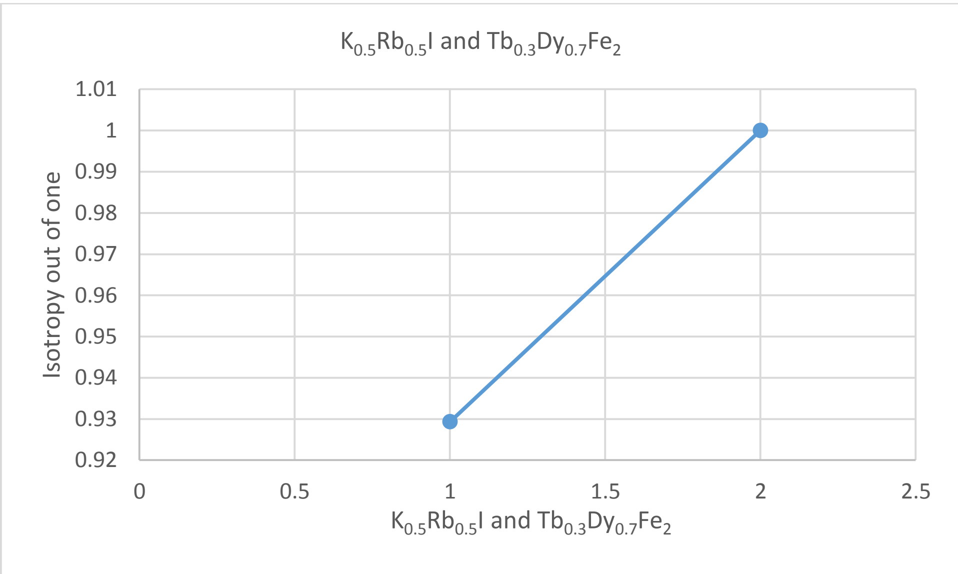
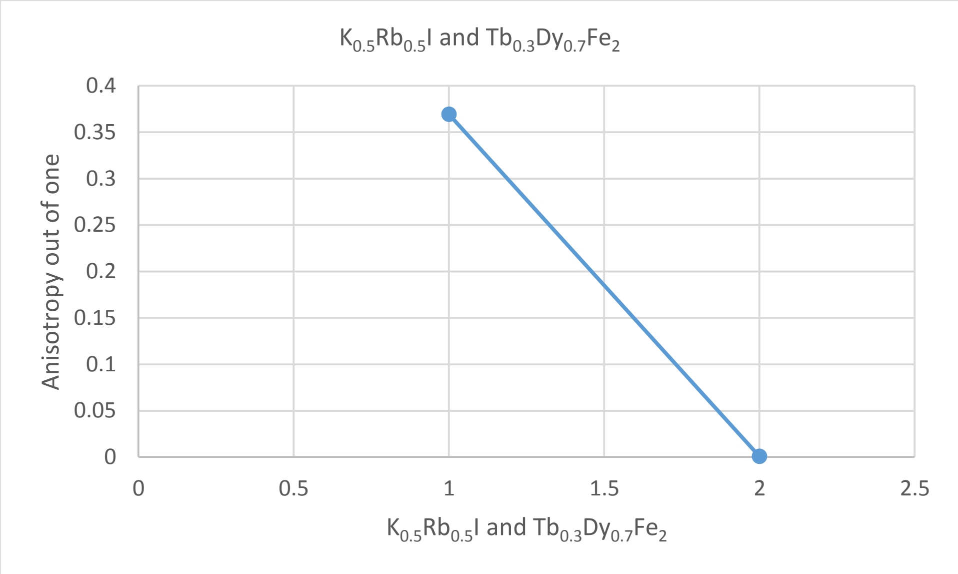
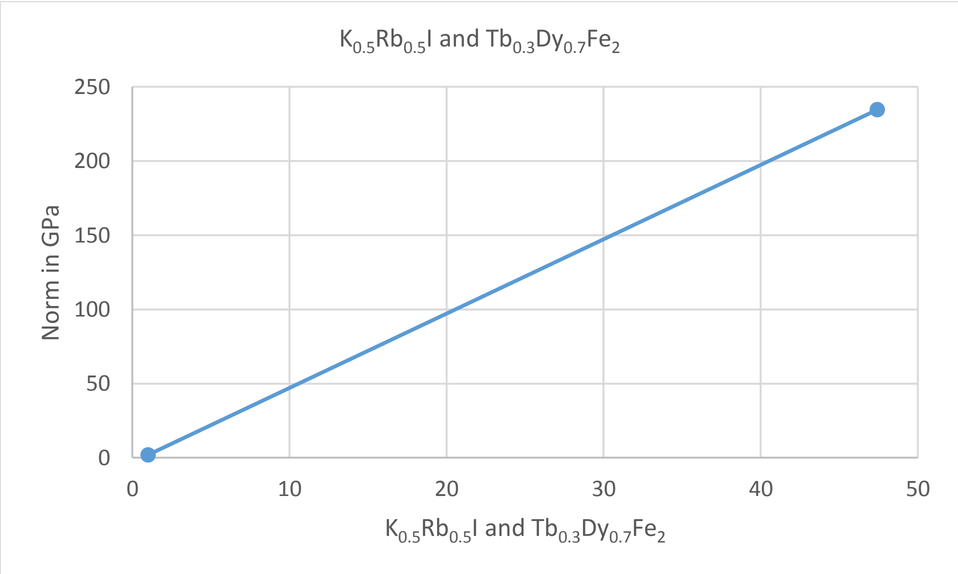


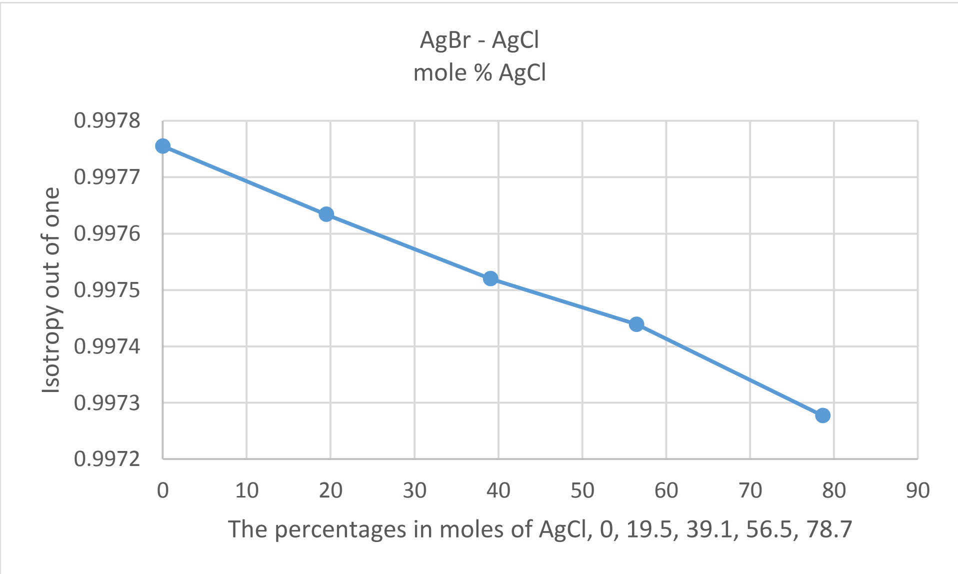
Graph 10. Isotropy Degree.



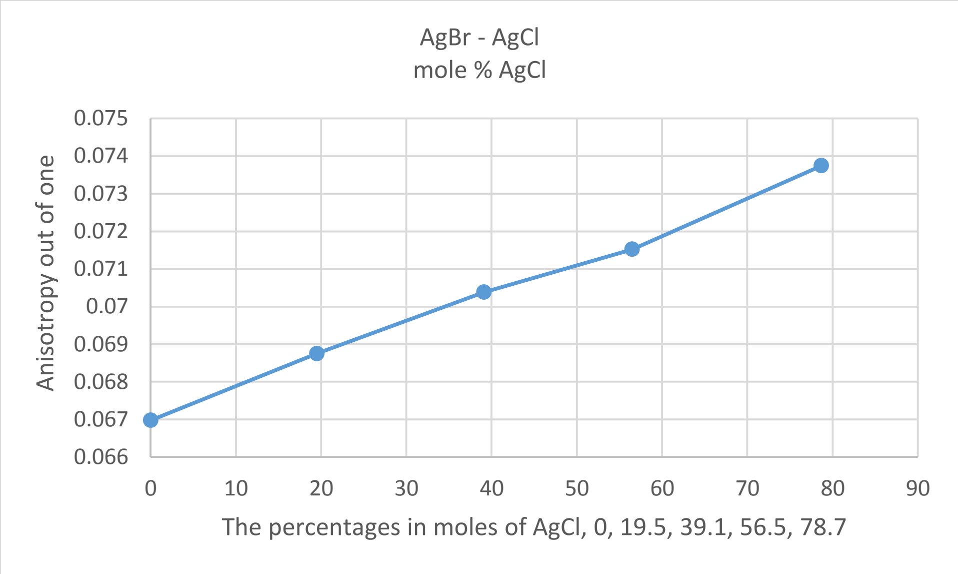
Graph 11. Anisotropy Degree.



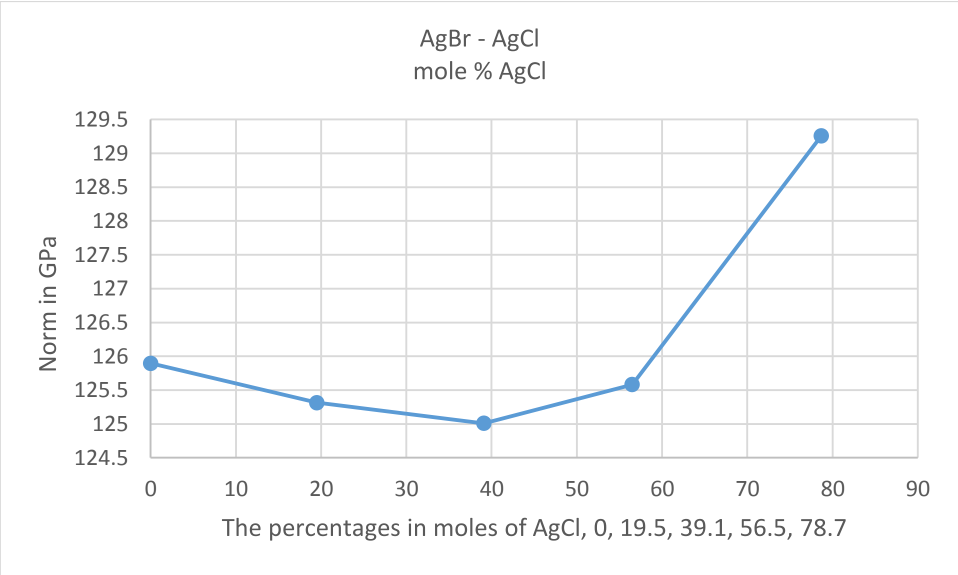
Graph 12. Elastically Srong.



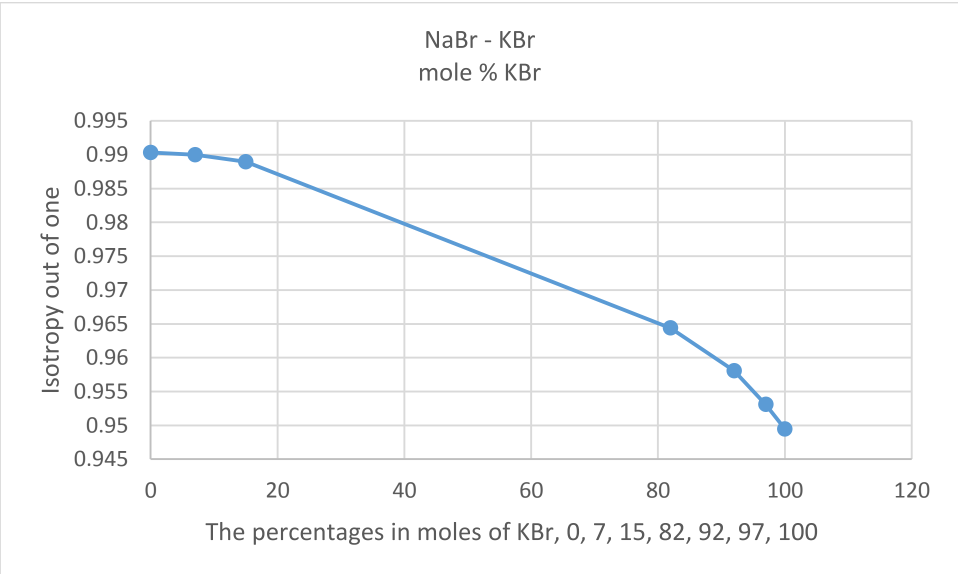
Graph 13. Isotropy Degree.



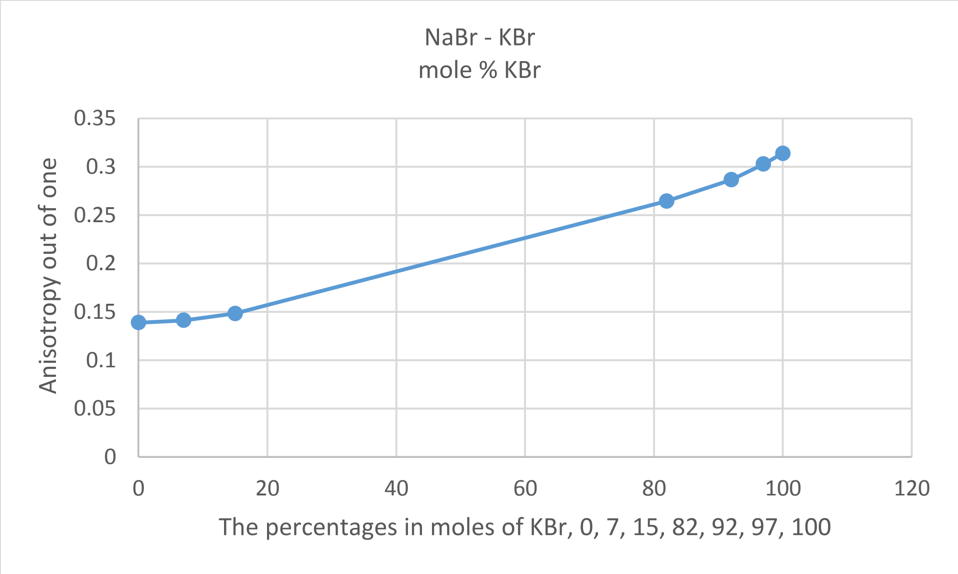
Graph 14. Anisotropy Degree.



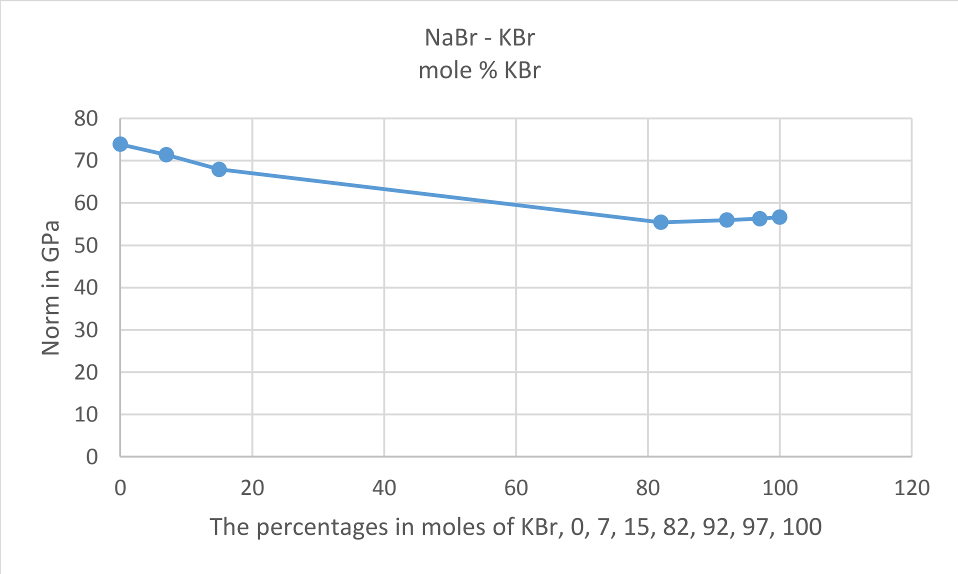
Graph 15. Elastically Srong.



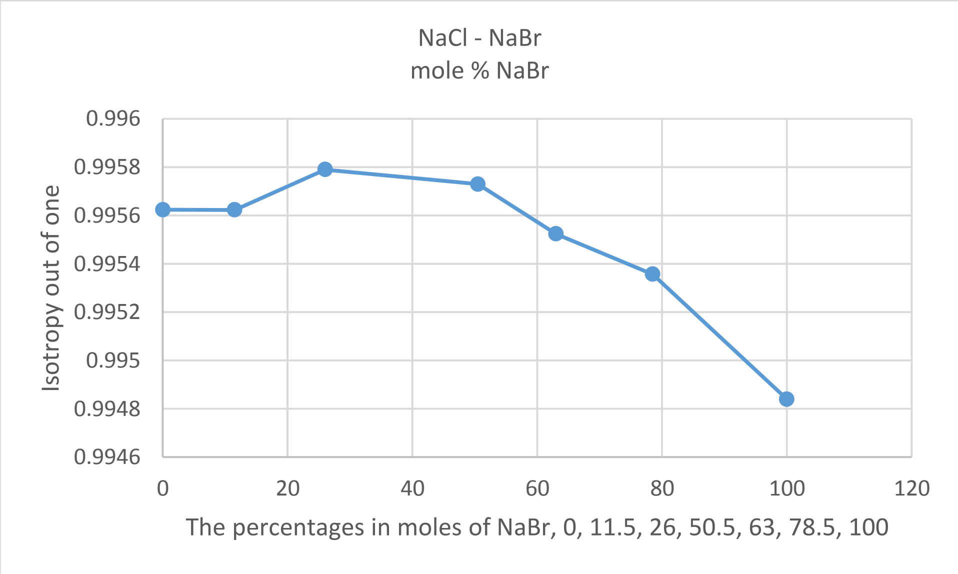
Graph 16. Isotropy Degree.



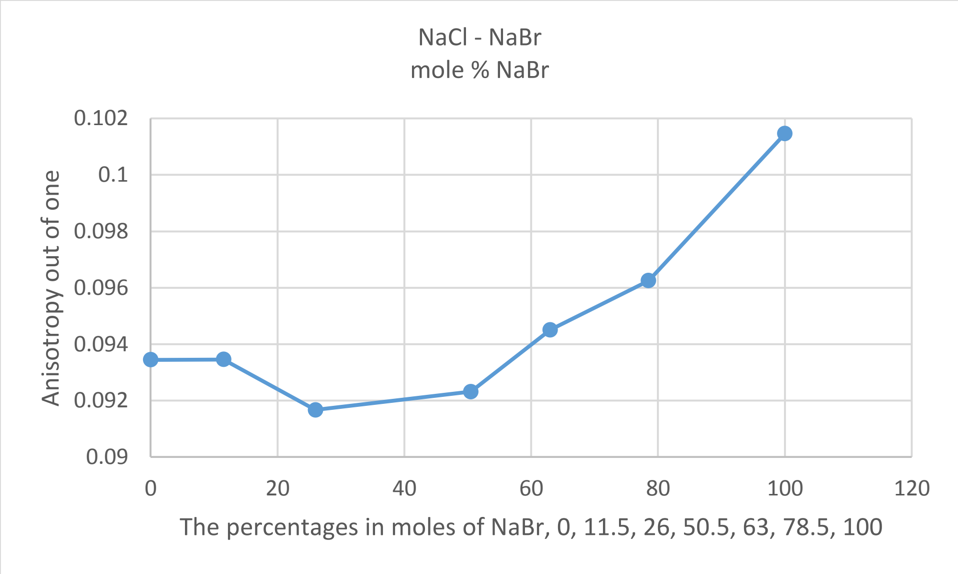
Graph 17. Anisotropy Degree.



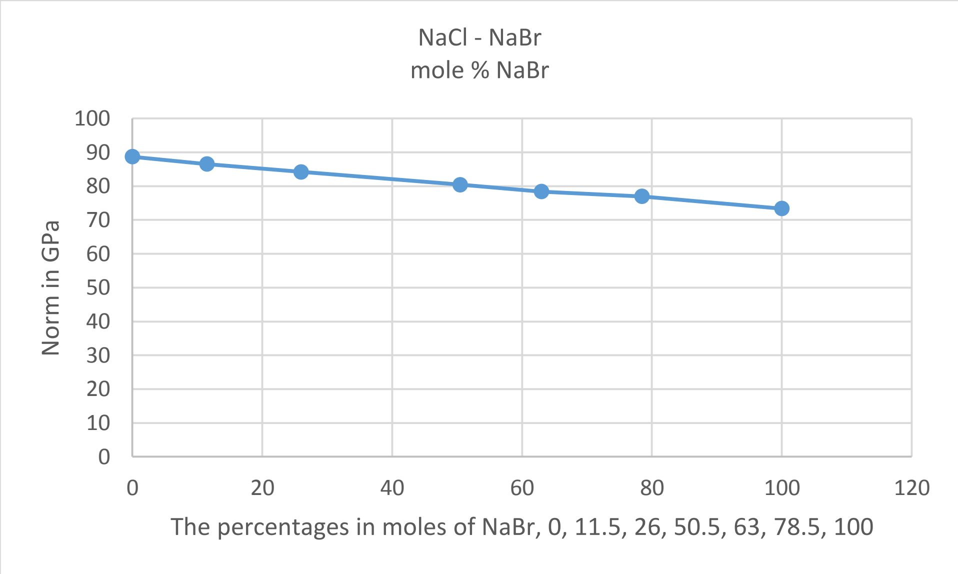
Graph 18. Elastically Srong.



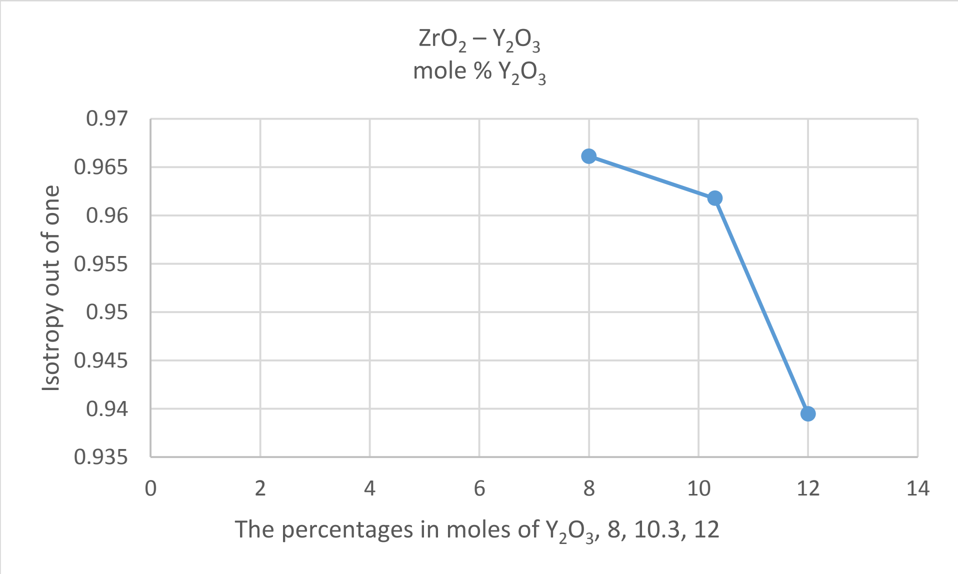
Graph 19. Isotropy Degree.



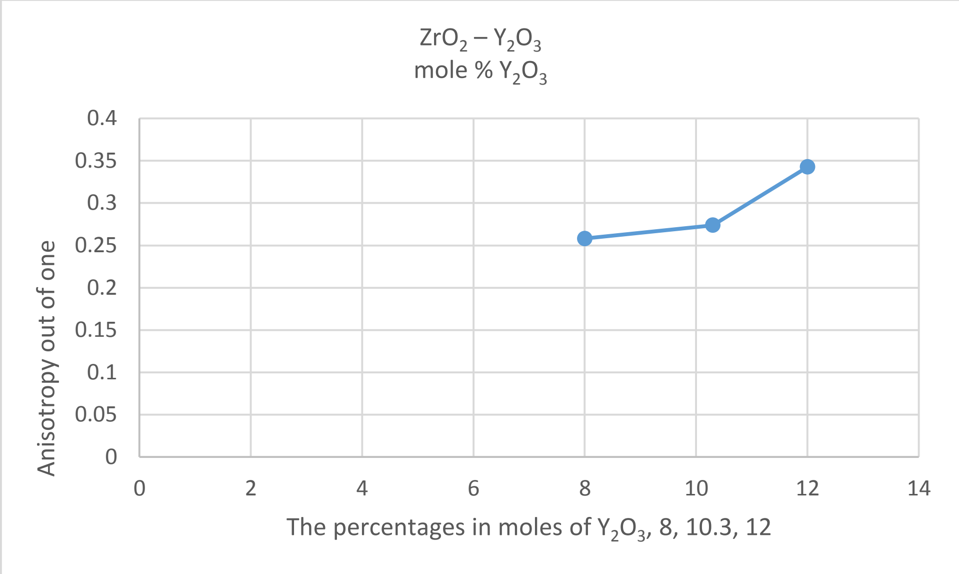
Graph 20. Anisotropy Degree.



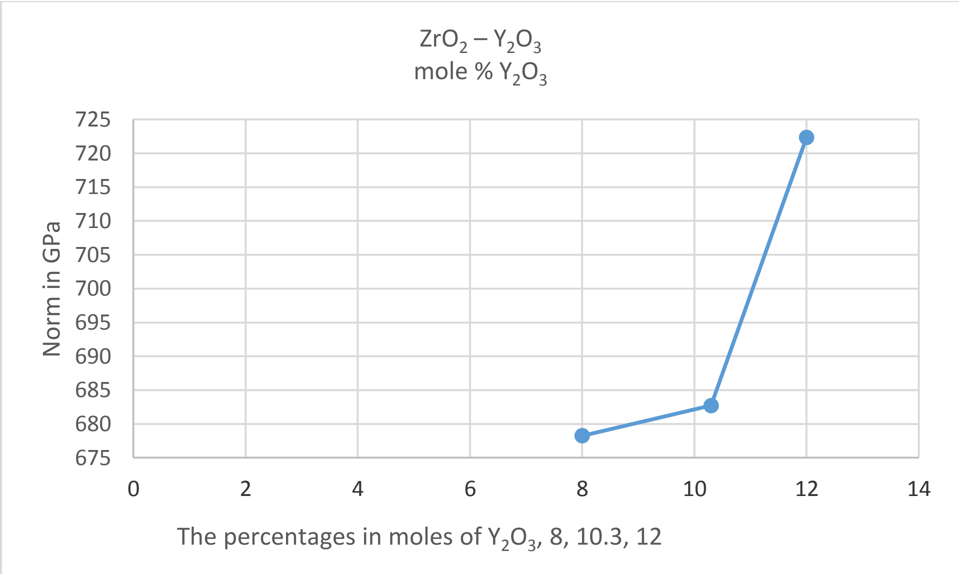
Graph 21. Elastically Srong.



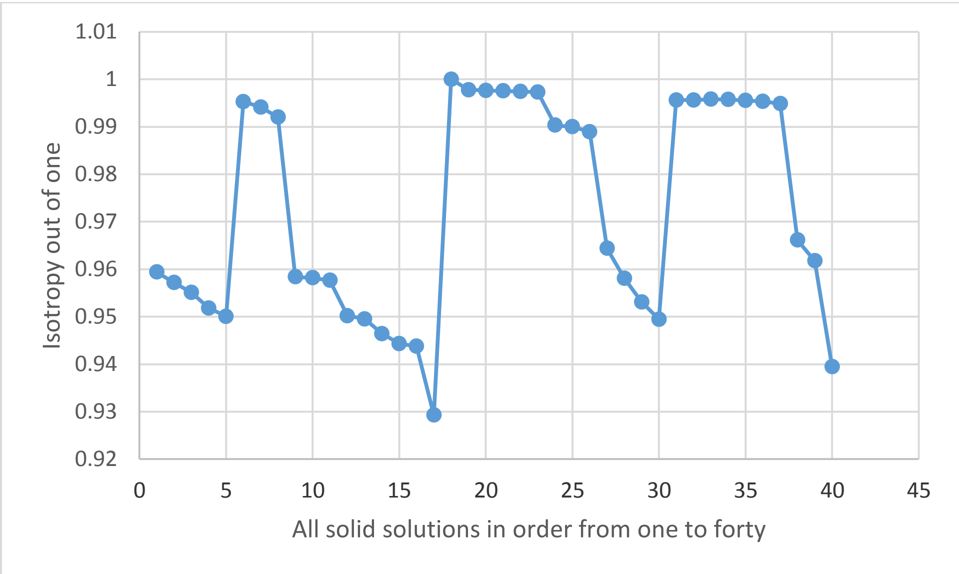
Graph 22. Isotropy Degree.



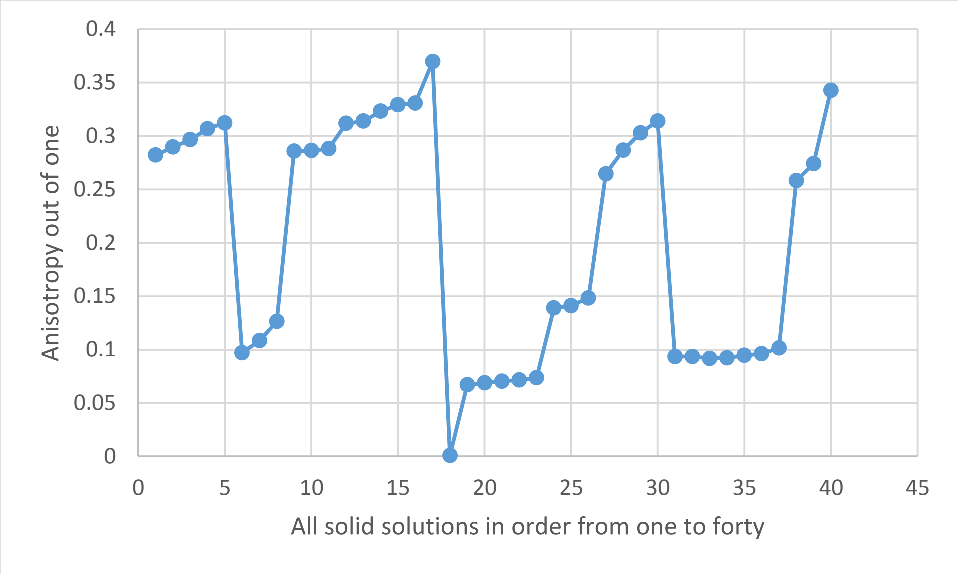
Graph 23. Anisotropy Degree.



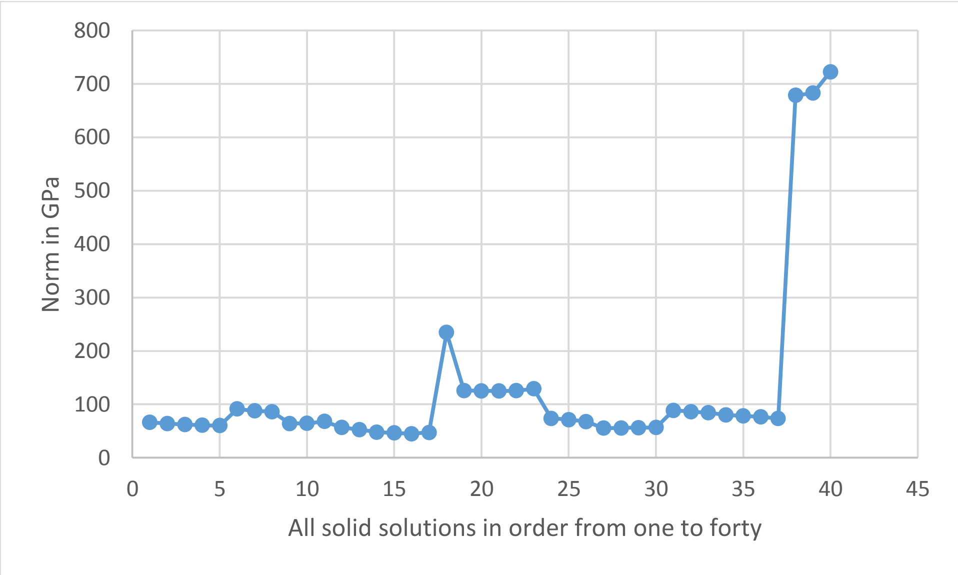
Graph 24. Elastically Srong.



Graph 25. Isotropy Degree.



Graph 26. Anisotropy Degree.



Graph 27. Elastically Srong.

III. CONCLUSION AND RESULTS

From table 2 and the Graphs (Graph 1 to Graph 27), and analyzing the ratio N_s/N we can conclude that **$Tb_{0.3}Dy_{0.7}$ Fe_2** is the most isotropic solid solution with highest value of N_s/N (**1.0**) and lowest value of N_n/N (**0.00078**) and **AgBr – AgCl with zero mole % AgCl** is the second most isotropic solid solution with highest value of N_s/N (**0.997755**) and lowest value of N_n/N (**0.066976**), and also can be noticed that as the **mole % AgCl** increases the isotropy decreases and the anisotropy increases, and **$K_{0.5}Rb_{0.5}I$,** is the most anisotropic solid solution with highest value of N_n/N (**0.369365**) and with lowest value of N_s/N (**0.929284**), and **$ZrO_2 – Y_2O_3$ with 12 mole % Y_2O_3** is the second most anisotropic solid solution with highest value of N_n/N (**0.342594**) and with lowest value of N_s/N (**0.939484**), and also can be noticed that as the **mole % Y_2O_3** increases the isotropy decreases and the anisotropy increases, because for isotropic material N_s/N = **1**, and N_d/N = **0** and N_n/N = **0**. Which means that as the value of N_n/N increases the anisotropy increases? And also the elastically strongest material is **$ZrO_2 – Y_2O_3$ with 12 mole % Y_2O_3**, which has the highest value of. **N** (**722.3109**), and the elastically lowest strongest is KBr – KI 100 mole % KI, which has the lowest value of **N** (**44.90313**).

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