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Abstract – *In present the work, we have theoretically calculated some important thermoelastic properties of nanomaterials under high compression, such as pressure, isothermal bulk modulus and percentage deviation of pressure of nanomaterials by using four different Equation of States (EOSs): viz. (I) Birch-Murnaghan EOS, (II) Bardeen EOS (III) Poirier- Tarantola and (IV) Suzuki EOS for 37nm* Al_2O_3*, 67nm* Al_2O_3*, 3C-SiC, nano-Ni and nano-ε-Fe nanomaterials. The result shows that the pressures increase as compression increases, which is in good agreement with experimental value. The bulk modulus also increases as compression increases, and computed value of percentage deviation in pressure at high compression this is demonstrates satisfying result across the entire compression range but the nano-ε-Fe nanomaterial percentage deviation shows excellent result with Poirier -Tarantola EOS.*

Keywords- *High compression, Nanomaterials, Equation of states, Isothermal bulk modules, Grüneisen parameter*

Introduction-

Alumina ceramic (Al_2O_3) is known for its fireproof properties. good strength and low thermal expansion coefficient, making it suitable for high temperature structural and substrate applications. Despite these advantages, Al2O3 suffer from low ductility and low fracture toughness, prompting the incorporation of metals such as aluminum, cobalt, or alloys into ceramics to enhance their toughness [1-6]. Al_2O_3 ais widely utilized in various application such as soft abrasive, catalyst, absorbent, coating, and catalyst carrier. Several synthesis approaches including microwave sintering, high-pressure sintering and plasma-assisted sintering are employed to produce highly dense γ-Al2O3 while minimizing excessive grain growth [7-10].

Silicon carbide (SiC) is a high-quality technical grade ceramic belonging to group IV-IV of the periodic table. It exhibits a wide variety of polytypes with unique structural and electronic properties due to the strong covalent bonds formed between silicon (Si) and carbon (C) atoms within its crystal lattice. SiC possesses high strength, a high melting point, high elastic modulus, a wide energy band gap, low thermal expansion, low density, high thermal conductivity and high hardness. Additionally, it demonstrates excellent thermal shock resistance, and chemical inertness. Due to its strength and hardness SiC is used in applications such as vehicles brakes, clutches, and ceramic plates for bullet proof vests [11-12].

In recent years, nano–Ni has garnered more attention to researchers. Researchers have conducted in-depth studies aimed at understanding its properties of such as its electrical behaviors, magnetic mechanics, diffusion coefficient and vibrational modes. Nano–Ni is known for its high conductive and its nanoparticles are available in various forms, including coated and dispersed forms. [13-14].

Iron (Fe) is a highly reactive element to both air and water due to oxygen, and nano-Fe exhibits even higher reactivity compare to bulk Fe. Nano-ε-Fe possesses unique physical properties such as ferromagnetic resonance, magnetoelectric coupling and highest coercivity. These

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properties find applications in magnetic field-tunable devices and magnetic recording devices. Researchers have conducted extensive investigations into the properties of nano-ε-Fe, including surface passivation magnetic, thermal, electrical and mechanical properties, on a large scale [15-29].

In this present work, we calculated the thermoelastic properties viz. Pressure and isothermal bulk modulus at high compression behavior of some nanomaterials viz. 37nm Al_2O_3, 67nm Al_2O_3, 3C-SiC, nano-Ni and nano-ε-Fe nanomaterials for using isothermal equation of states Suzuki EOS, Birch-Murnaghan EOS, Bardeen EOS, Poirier- Tarantola and Birch-Murnaghan EOS and experimental studies to under the high-pressure behavior of nanomaterials. Further analyze the variation of percentage deviation in pressure under high compression.

Method of analysis- We have investigated the thermoelastic properties of nanomaterials under high compression. Here, we have used four different isothermal EOSs. All the equation of states based on interatomic Potential Model. Which are given below [27, 29-31]:

Suzuki Equation of State-

The Gruneisen theory of thermal expansion based on the Mie-Gruneisen equation of state has followed by San-Miguel and Suzuki. The Mie-Gruneisen equation is written as,

$$PV+X(V)=\gamma E\text{Th} \tag{A}$$

In above equation P is pressure, $X(V) = (d\Phi/dV)$, Φ is Potential energy as a volume's function only, γ and ETh is Gruneisen parameter regarded as constant and the thermal energy of lattice vibration. Then after applying Taylor's expansion to the second term in equation (A) with respect to the second order,

$$P = \frac{K_0}{2(K'_0-1)}\left[\left\{\left(\frac{V}{V_0}-1\right)(K'_0-1)-1\right\}^2-1\right] \tag{1}$$

$$K_T = \frac{K_0}{2(K'_0-1)}\left[2\left\{\left(\frac{V}{V_0}-1\right)(K'_0-1)-1\right\}\left(\frac{V}{V_0}\right)(1-K'_0)\right] \tag{2}$$

Bardeen Equation of state-

Bardeen EOS The Bardeen equation of state is derived from the potential function E(r) and the Bardeen equation is written as,

$$P = 3K_0\left[\left(\frac{V}{V_0}\right)^{-\frac{5}{3}}-\left(\frac{V}{V_0}\right)^{-\frac{4}{3}}\right]\left[1-\frac{3}{2}(K'_0-3)\left(\left(\frac{V}{V_0}\right)^{-\frac{1}{3}}-1\right)\right] \tag{3}$$

$$K_T = 3K_0\left[\left\{\left(\frac{V}{V_0}\right)^{-\frac{5}{3}}-\left(\frac{V}{V_0}\right)^{-\frac{4}{3}}\right\}\left\{\frac{1}{2}(3-K'_0)\left(\frac{V}{V_0}\right)^{-\frac{1}{3}}\right\}+\left\{1-\frac{3}{2}(K'_0-3)\left(\left(\frac{V}{V_0}\right)^{-\frac{1}{3}}-1\right)\right\}\left\{\frac{1}{3}\left(5\left(\frac{V}{V_0}\right)^{-\frac{5}{3}}-4\left(\frac{V}{V_0}\right)^{-\frac{4}{3}}\right)\right\}\right] \tag{4}$$

Poirier-Tarantola Equation of State-

Poirier and Tarantola derived an equation define strain as Є= log(l0/l) and the Poirier-Tarantola EOS is written as,

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$$P = K_0\left(\frac{V_0}{V}\right)\left[ln\left(\frac{V_0}{V}\right) + \left\{\left(\frac{K'_0-2}{2}\right)\right\}\left\{ln\left(\frac{V_0}{V}\right)\right\}^2\right] \tag{5}$$

$$K_T = K_0\left(\frac{V_0}{V}\right)\left[1 + (K'_0 - 2)\left\{ln\left(\frac{V_0}{V}\right)\right\}\right] + \left[ln\left(\frac{V_0}{V}\right) + \left\{\left(\frac{K'_0-2}{2}\right)\right\}\left\{ln\left(\frac{V_0}{V}\right)\right\}^2\right] \tag{6}$$

Birch-Murnaghan Equation of state-

Birch-Murnaghan EOS is based on finite strain theory and the Birch-Murnaghan EOS is written as,

$$P = \frac{3}{2}K_0\left[\left(\frac{V}{V_0}\right)^{-\frac{7}{3}} - \left(\frac{V}{V_0}\right)^{-\frac{5}{3}}\right]\left[1 + \frac{3}{4}(K'_0 - 4)\left(\left(\frac{V}{V_0}\right)^{-\frac{2}{3}} - 1\right)\right] \tag{7}$$

$$K_T = \frac{K_0}{2}\left[7\left(\frac{V}{V_0}\right)^{-\frac{7}{3}} - 5\left(\frac{V}{V_0}\right)^{-\frac{5}{3}}\right] + \frac{3}{8}K_0(K_0' - 4)\left(9\left(\frac{V}{V_0}\right)^{-\frac{9}{3}} - 14\left(\frac{V}{V_0}\right)^{-\frac{7}{3}} + 5\left(\frac{V}{V_0}\right)^{-\frac{5}{3}}\right) \tag{8}$$

From above equations (1,3,5 and 7) we can obtain the expression for isothermal bulk modulus (K_T) at pressure (P), by using below mentioned equation

$$K_T = -V\left(\frac{\partial P}{\partial V}\right)_T \tag{B}$$

Result & discussion- In this present work we have described the four different equation of states viz. Suzuki EOS, Bardeen EOS, Poirier-Tarantola EOS and Birch-Murnaghan EOS for calculating the thermoelastic properties of nanomaterials viz. pressure(P), isothermal bulk modulus and percentage deviation in pressure(P) at different compressions for, 67nm Al_2O_3, 3C-SiC, nano-Ni and nano-ε-Fe nanomaterials. The pressure calculated by using equation (1,3,5,7) and isothermal bulk modulus calculated by using equation (2,4,6,8). All the four EOS contain two parameters isothermal bulk modulus and first derivative of isothermal bulk modulus at zero pressure (K_0 and K'_0). It has been usual practice to adjust or to fit the parameters in order to achieve the agreement with the experimental values and its numeric value shown in table 1.

In Table .2, we have seen applicability of Suzuki EOS, Bardeen EOS, Poirier-Tarantola and Birch-Murnaghan EOS for 37nm Al_2O_3. We have seen that Birch-Murnaghan EOS is slightly deviate from experimental values, so this is best option to calculate pressure at high compression.

In Table .3, we have seen applicability of Suzuki EOS, Bardeen EOS, Poirier-Tarantola and Birch-Murnaghan EOS for 67nm Al_2O_3. We have seen that Poirier-Tarantola and Birch-Murnaghan EOS are slightly deviate from experimental values, so this is best option to calculate pressure at high compression.

In Table .4, we have seen applicability of Suzuki EOS, Bardeen EOS, Poirier-Tarantola and Birch-Murnaghan EOS for 3C-SiC. We have seen that Poirier-Tarantola and Birch-Murnaghan EOS are slightly deviate from experimental values, so this is best option to calculate pressure at high compression.

In Table .5, we have seen applicability of Suzuki EOS, Bardeen EOS, Poirier-Tarantola and Birch-Murnaghan EOS for Nano-Ni. We have seen that Poirier-Tarantola and Birch-

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Murnaghan EOS are slightly deviate from experimental values, so this is best option to calculate pressure at high compression.

In Table .6, we have seen applicability of Suzuki EOS, Bardeen EOS, Poirier-Tarantola and Birch-Murnaghan EOS for Nano-ε-Fe. We have seen that Poirier-Tarantola and Birch-Murnaghan EOS are slightly deviate from experimental values, so this is best option to calculate pressure at high compression.

Further finding the value of P we are using the value of K_0 and K'_0 in equation (1,3,5,7). We find the value of K_T Further substituting the values of P and K_T calculated by using equations (2,4,6 and 8). Further we find the value of percentage deviation in P at different compressions. The graphs plotted between the calculated value of P and experimental value of P at different compressions by using Suzuki EOS, Bardeen EOS, Poirier-Tarantola and Birch-Murnaghan EOS are shown in figure (1-5). Further the graphs plotted between calculated value of K_T at different compressions and the graph of K_T are shown in figure (6-10). The calculated value of pressure. Furthermore, the graph of percentage deviation in Pressure (P) at different compression shown in figure (11-15). The equation (1 and 2) represents the Suzuki EOS, the equation (3 and 4) represents the Bardeen EOS, the equation (5 and 6) represents the Poirier-Tarantola EOS and the equation (7-8) represents Birch-Murnaghan EOS respectively.

Table. 1

Input parameters use in this research work.

S.No.	Nanomaterial	K_0	K'_0	Reference
1	37 nm Al_2O_3	151	5.7	[32]
2	67 nm Al_2O_3	248	3.2	[32]
3	3C-SiC	220.6	4	[33]
4	Nano-Ni	185.4	4	[34]
5	Nano-ε-Fe	179	3.6	[35]

Table. 2

Calculated value of pressure (P), experimental value of pressure (P) at different compressions for 37 nm Al_2O_3 using (a) Suzuki EOS, (b) Bardeen EOS (c) Poirier- Tarantola and (d) Birch-Murnaghan EOS and percentage deviation in pressure (P)

V/V_0	P(a)	P(b)	P(c)	P(d)	P(exp) [36]	% deviation, P(a)	% deviation, P(b)	% deviation, P(c)	% deviation, P(d)
1	0	0	0	0	0	0	0	0	0
0.98928	1.659499	1.645055	1.677896	1.678214	4.01575	58.67525	59.03492	58.21712	58.20921
0.9197	14.4134	13.72309	15.87178	16.03898	17.85595	19.27954	23.14556	11.11212	10.17569
0.89982	18.68847	17.67206	21.17362	21.52092	22.92747	18.48876	22.92189	7.649564	6.1348

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0.88274	22.58541	21.2636	26.25806	26.84886	27.88284	18.99887	23.73947	5.827167	3.708295
0.87	25.62697	24.06901	30.39801	31.2399	31.94779	19.78486	24.66143	4.850992	2.215757
0.86006	28.08004	26.33632	33.84923	34.9372	37.0193	24.14757	28.85786	8.563283	5.624367
0.85012	30.60324	28.67501	37.50592	38.89126	42.41988	27.85638	32.40196	11.58409	8.31832
0.84018	33.19655	31.08751	41.37939	43.12092	47.60754	30.27039	34.70044	13.08227	9.424178
0.81937	38.85289	36.38858	50.24483	52.96064	51.09178	23.95471	28.77802	1.657698	3.657854
0.80865	41.88662	39.25794	55.24267	58.60465	56.39558	25.72712	30.38827	2.044324	3.917091

Table. 3

Calculated value of pressure (P), experimental value of pressure (P) at different compressions for 67 nm Al_2O_3 using (a) Suzuki EOS, (b) Bardeen EOS (c) Poirier- Tarantola and (d) Birch-Murnaghan EOS and percentage deviation in pressure (P)

V/V_0	P(a)	P(b)	P(c)	P(d)	P(exp) [36]	% deviation, P(a)	% deviation, P(b)	% deviation, P(c)	% deviation, P(d)
1	0	0	0	0	0	0	0	0	0
0.98421	1.659499	4.010283	4.04879	4.048772	5.059	21.25053	20.72973	19.96858	19.96893
0.95492	14.4134	11.97442	12.31128	12.31067	12.94942	9.384158	7.529329	4.927971	4.932623
0.94508	18.68847	14.81262	15.32486	15.32365	15.8995	9.160784	6.835935	3.614195	3.621836
0.92235	22.58541	21.70357	22.78762	22.78327	23.38058	10.60079	7.172664	2.536109	2.554719
0.91709	25.62697	23.36766	24.62022	24.61464	25.18733	10.91979	7.224552	2.251581	2.273736
0.9016	28.08004	28.42729	30.26341	30.25258	30.69227	11.88465	7.379643	1.397287	1.432567
0.88978	30.60324	32.4539	34.82996	34.81298	35.46322	13.57622	8.485743	1.785675	1.833566
0.87694	33.19655	36.99805	40.06256	40.03602	40.96817	15.4219	9.690731	2.210521	2.275309
0.86411	38.85289	41.72319	45.59131	45.5513	46.54368	16.77008	10.35692	2.046177	2.13214

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Table.4

Calculated value of pressure (P), experimental value of pressure (P) at different compressions for 3C-SiC using (a) Suzuki EOS, (b) Bardeen EOS (c) Poirier- Tarantola and (d) Birch-Murnaghan EOS and percentage deviation in pressure (P)

V/V_0	P(a)	P(b)	P(c)	P(d)	P(exp) [36]	% deviation, P(a)	% deviation, P(b)	% deviation, P(c)	% deviation, P(d)
1	0	0	0	0	0	0	0	0	0
0.99343	1.463625	1.463728	1.473389	1.473422	1.23372	18.63513	18.64344	19.42656	19.42924
0.9898	2.284547	2.284932	2.308408	2.308533	1.87369	21.92768	21.94824	23.20115	23.20782
0.98754	2.800049	2.800752	2.83596	2.836189	3.14907	11.08331	11.06098	9.942933	9.935651
0.98164	4.161759	4.164022	4.241483	4.242229	3.76162	10.63741	10.69756	12.75681	12.77665
0.97528	5.655438	5.660993	5.80344	5.805296	5.83697	3.110041	3.014874	0.574437	0.542642
0.97195	6.448183	6.456324	6.641121	6.643859	6.68723	3.57468	3.452945	0.689504	0.64856
0.95972	9.422646	9.447027	9.838881	9.847287	10.03796	6.12987	5.886979	1.983257	1.899515
0.95357	10.95579	10.99335	11.52142	11.53453	10.80593	1.386868	1.734414	6.621282	6.742623
0.95018	11.8116	11.85814	12.47093	12.48729	12.53386	5.762498	5.391151	0.502097	0.371538
0.94673	12.69035	12.74744	13.45367	13.47388	13.81138	8.116686	7.703383	2.58998	2.443631
0.9434	13.54602	13.6147	14.4182	14.44269	15.03434	9.899483	9.442627	4.098206	3.935315
0.93901	14.68527	14.77156	15.71417	15.74522	16.17715	9.222148	8.688712	2.861932	2.669988
0.93252	16.39286	16.51045	17.6821	17.725	17.50739	6.366067	5.694373	0.99793	1.242934

Table.5

Calculated value of pressure (P), experimental value of pressure (P) at different compressions for nano-Ni using (a) Suzuki EOS, (b) Bardeen EOS (c) Poirier- Tarantola and (d) Birch-Murnaghan EOS and percentage deviation in pressure (P)

V/V_0	P(a)	P(b)	P(c)	P(d)	P(exp) [36]	% deviation, P(a)	% deviation, P(b)	% deviation, P(c)	% deviation, P(d)
1	0	0	0	0	0	0	0	0	0

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0.99524	0.888805	0.888838	0.893083	0.893093	2.10607	57.79793	57.79638	57.59481	57.59431
0.96091	7.672231	7.690938	8.000249	8.006683	9.79826	21.69803	21.50711	18.35031	18.28464
0.94374	11.31084	11.36752	12.03419	12.05438	14.09266	19.73948	19.33733	14.60671	14.46342
0.92728	14.95294	15.07724	16.23508	16.28092	17.20729	13.10116	12.37876	5.649993	5.383563
0.90027	21.25594	21.58495	23.90907	24.03769	22.16238	4.089972	2.605458	7.881344	8.461663
0.87987	26.28542	26.87188	30.41858	30.65846	29.93321	12.18642	10.22719	1.621506	2.422886
0.86833	29.23303	30.01399	34.40045	34.72836	33.14222	11.79518	9.438812	3.796472	4.785844
0.85524	32.66622	33.7174	39.19962	39.65451	38.63214	15.4429	12.7219	1.468943	2.646412
0.84624	35.08198	36.35288	42.68366	43.24532	43.11531	18.63219	15.68453	1.001163	0.301539
0.834	38.43972	40.05839	47.6776	48.41407	51.1693	24.87737	21.71402	6.823811	5.384542
0.82415	41.20234	43.14549	51.9222	52.82756	54.7401	24.73098	21.1812	5.14778	3.493849

Table.6

Calculated value of pressure (P), experimental value of pressure (P) at different compressions for nano-ε-Fe using (a) Suzuki EOS, (b) Bardeen EOS (c) Poirier- Tarantola and (d) Birch-Murnaghan EOS and percentage deviation in pressure (P)

V/V_0	P(a)	P(b)	P(c)	P(d)	P(exp) [36]	% deviation, P(a)	% deviation, P(b)	% deviation, P(c)	% deviation, P(d)
1	0	0	0	0	0	0	0	0	0
0.93925	11.73304	11.93435	11.03774	12.55486	11.03774	6.299332	8.123118	0	13.74484
0.90567	18.95567	19.54162	19.86011	21.18314	19.86011	4.554057	1.603642	0	6.661724
0.88237	24.2756	25.30126	28.10179	28.02852	28.10179	13.61548	9.965653	0	0.260736
0.86163	29.22356	30.7898	34.49954	34.79788	34.49954	15.29289	10.753	0	0.864752
0.85168	31.66841	33.55142	38.00403	38.29386	38.00403	16.67093	11.71616	0	0.762618
0.8408	34.3945	36.67109	42.08922	42.31504	42.08922	18.28193	12.87297	0	0.536517
0.83195	36.65258	39.28831	46.06234	45.74721	46.06234	20.4283	14.70622	0	0.684131

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A graph plotted between Pressure with high compression for 37nm Al_2O_3, 67nm Al_2O_3, 3C-SiC, nano-Ni and nano-*ε*-Fe nanomaterials are shown in figure (1-5):

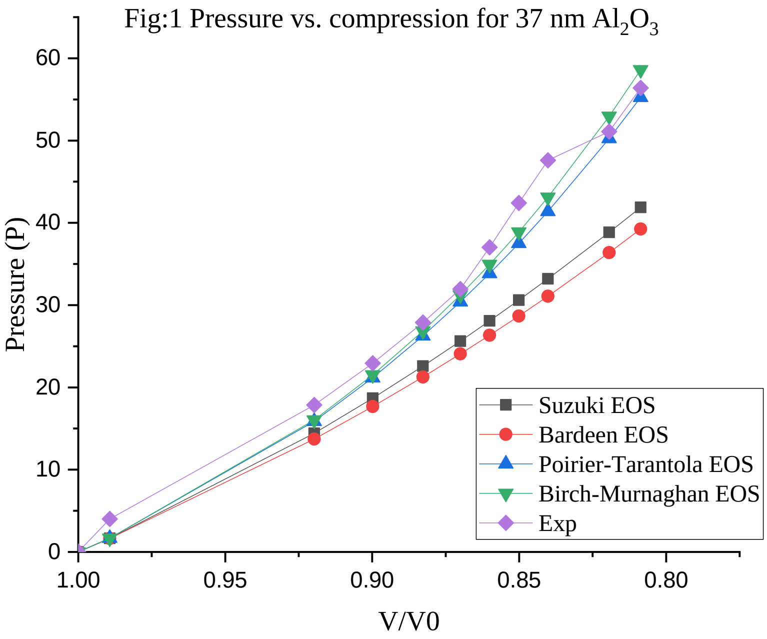

Fig:1 Pressure vs. compression for 37 nm Al_2O_3

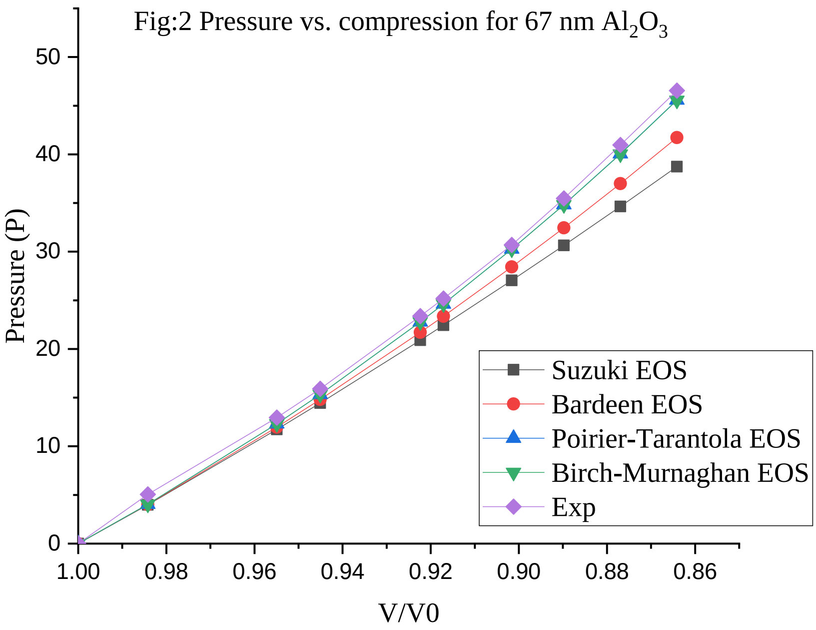

Fig:2 Pressure vs. compression for 67 nm Al_2O_3

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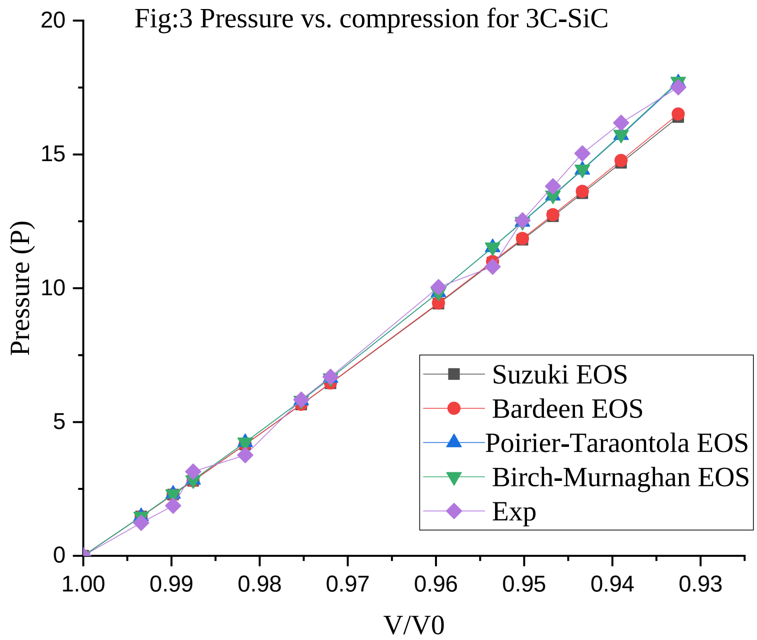

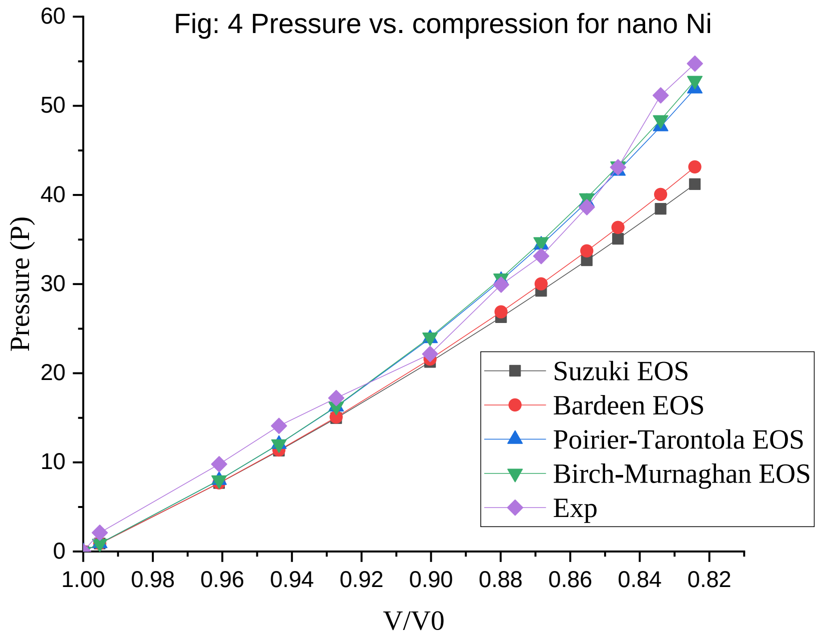

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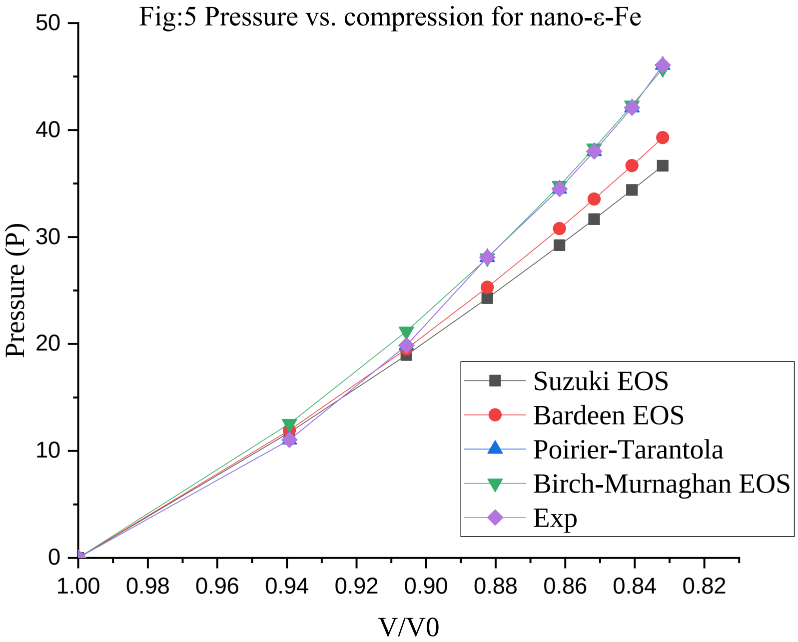
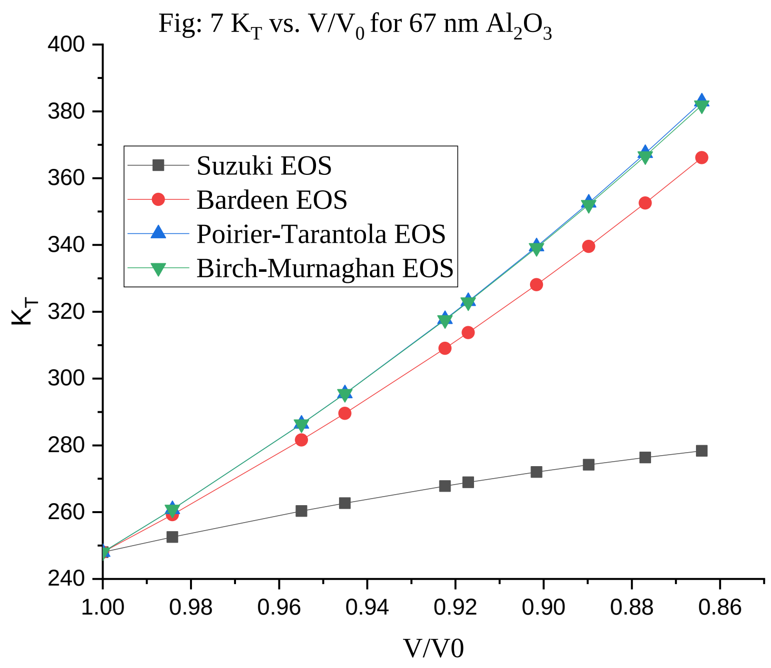


From figure (1-5) it is clear that increasing the pressure leads to an increase in the compression value for all the five nanomaterials viz. 37nm Al_2O_3, 67nm Al_2O_3, 3C-SiC, nano-Ni and nano-ε-Fe nanomaterials. Furthermore, for 37nm Al_2O_3 the Birch-Murnaghan EOS shows excellent agreement with experimental pressure value. Additionally, for 67nm Al_2O_3, 3C-SiC and Nano-Ni nanomaterials, both the Birch- Murnaghan EOS and Poirrier – Tarantola EOS demonstrate excellent agreement with the experimental value across the entire range. However, for nano-ε-Fe, the Suzuki EOS and Bardeen EOS initially shows good agreement with experimental pressure values up to a volume compression range (V/V_0) = 0.90 at 20 GPa, subsequently, the Birch- Murnaghan EOS exhibits excellent agreement with experimental values but Poirier-Tarantola EOS calculated pressure value fully satisfied with experimental values.

A graph plotted between isothermal bulk modulus with high compression for 37nm Al_2O_3, 67nm Al_2O_3, 3C-SiC, nano-Ni and nano-ε-Fe nanomaterials are shown in figure (6-10):

DOI: https://doi.org/10.71058/jodac.v9i5022



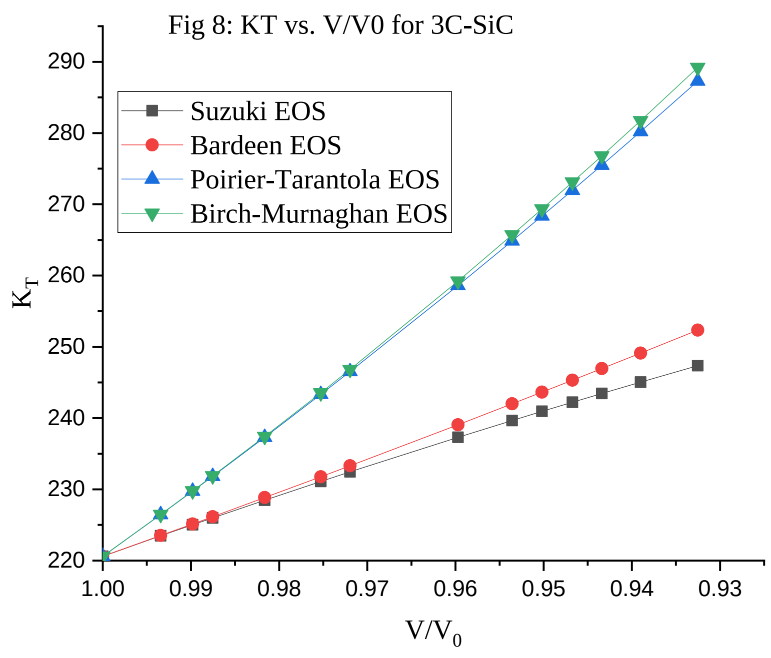


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Fig:9 K_T vs. V/V_0 for nano-Ni

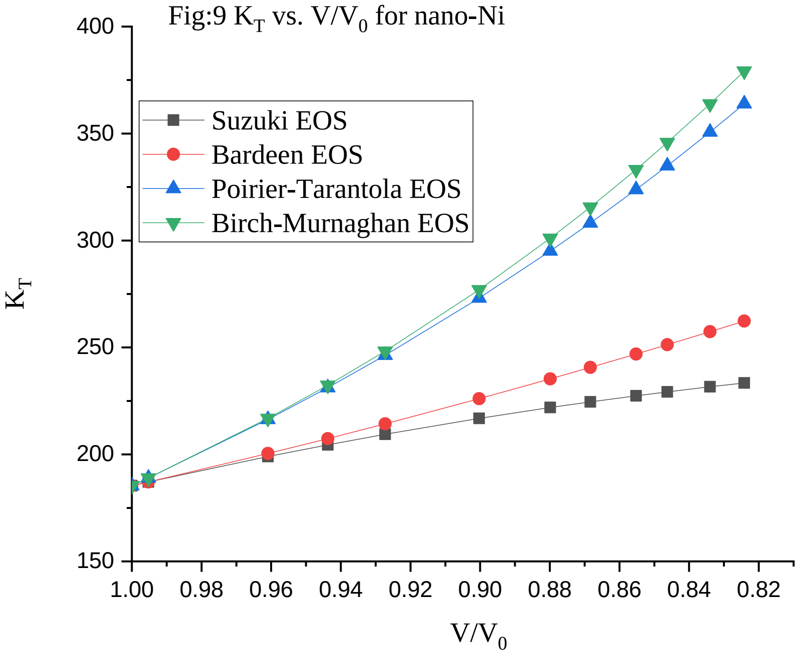
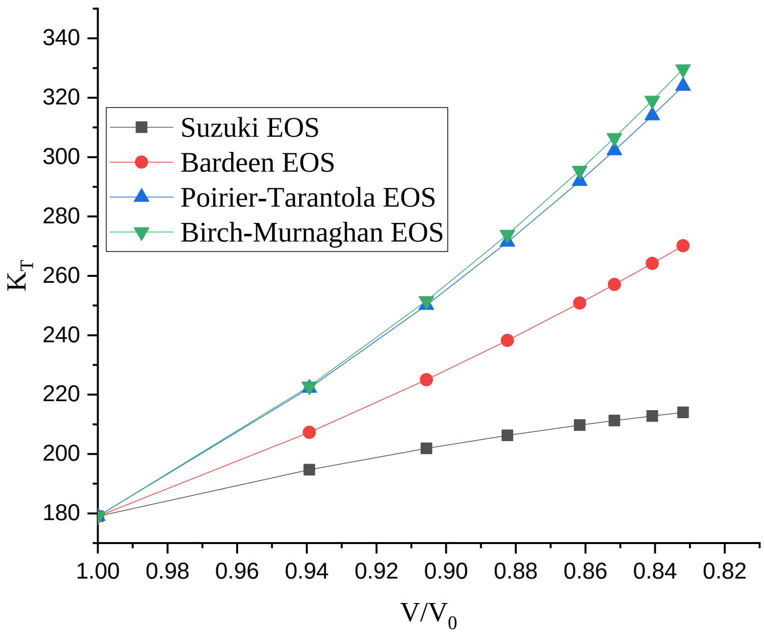


Fig: 10 K_T vs. V/V_0 for nano- ε-Fe



From figure (6-10) it is clear that an increase in the isothermal bulk modulus (K_T), results in higher compression values across all the five nanomaterials viz. 37nm Al_2O_3, 67nm Al_2O_3, 3C-SiC, nano-Ni and nano-ε-Fe nanomaterials. For 37nm Al_2O_3 all four EOS exhibit significant differences in the compression range. Similarly, in the case of 67nm Al_2O_3, the Birch-Murnaghan EOS and Poirrier – Tarantola EOS demonstrate good agreement, whereas the Suzuki EOS and Bardeen EOS do not match within the compression range. Conversely, for

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3C-SiC, Nano-Ni and nano-ε-Fe nanomaterials, the Birch- Murnaghan EOS and Poirrier – Tarantola exhibit excellent agreement throughout the entire range, while the Suzuki EOS and Bardeen EOS do not align within the compression range.

A graph plotted between percentage deviation in pressure (P) with high compression for 37nm Al_2O_3, 67nm Al_2O_3, 3C-SiC, nano-Ni and nano-ε-Fe nanomaterials are shown in figure (11-15):

Fig:11 % Deviation (pressure) vs V/V_0 for 37nm Al_2O_3

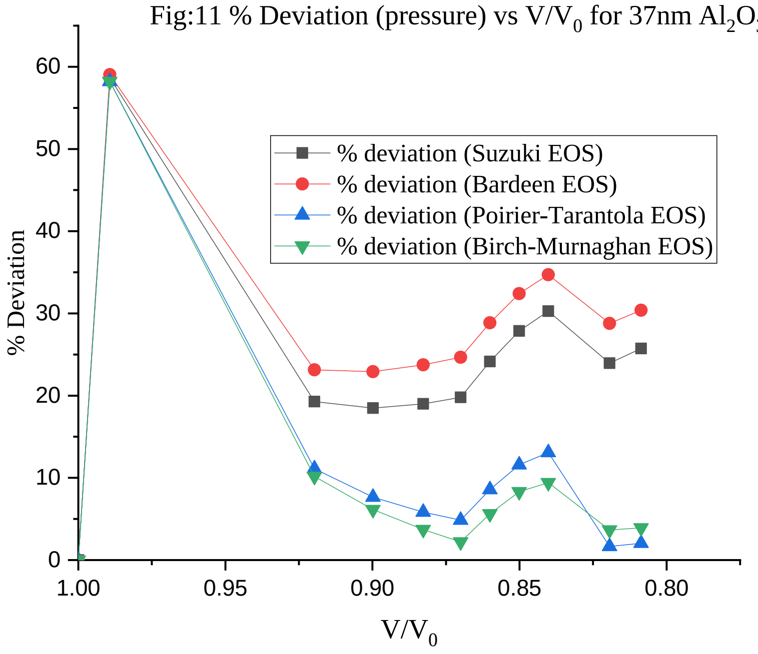

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Fig: 12 % Deviation (Pressure) vs V/V_0 for 67 nm Al_2O_3

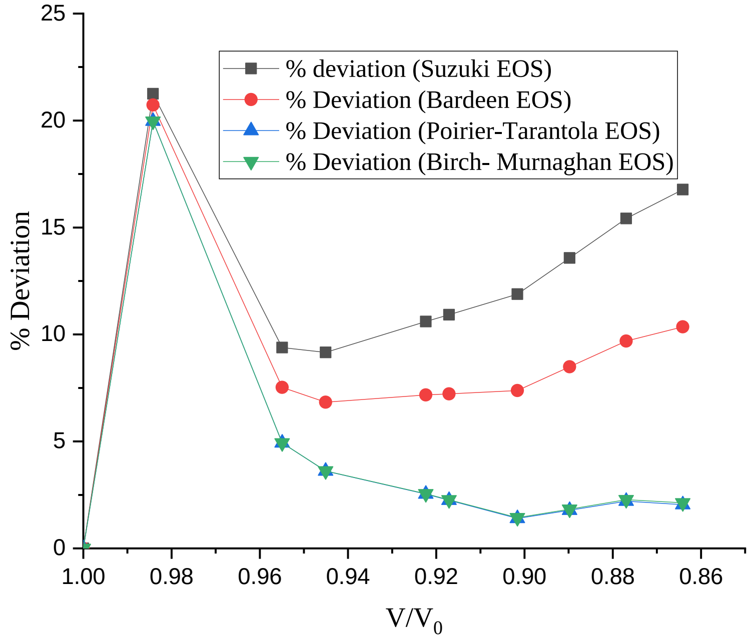
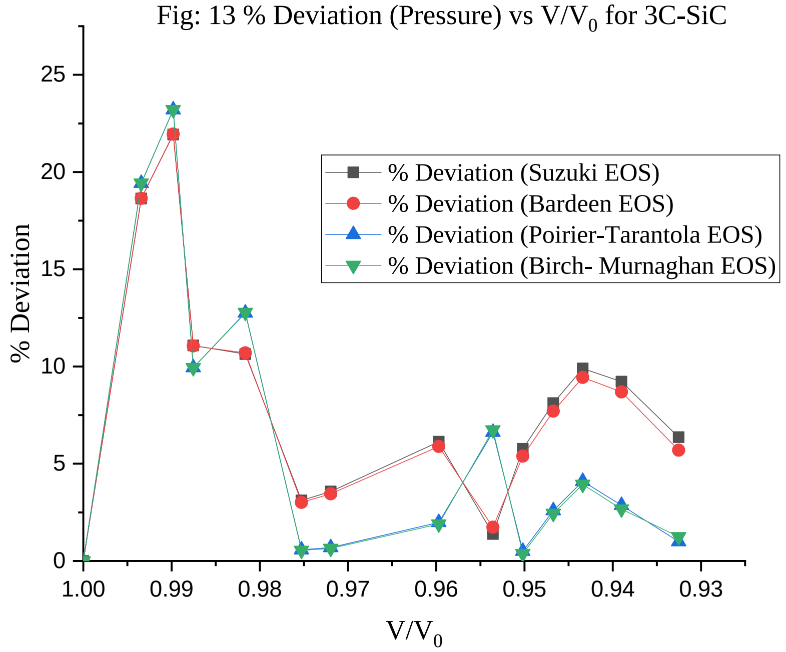


Fig: 13 % Deviation (Pressure) vs V/V_0 for 3C-SiC



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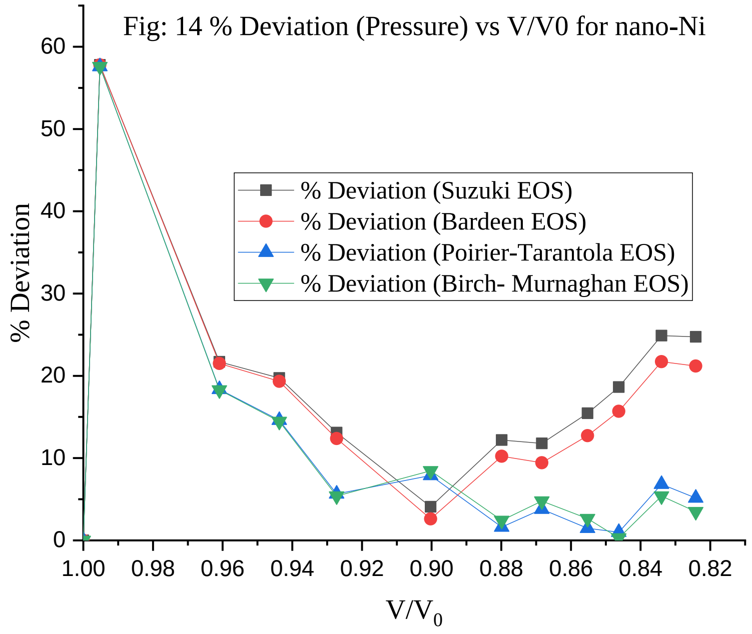

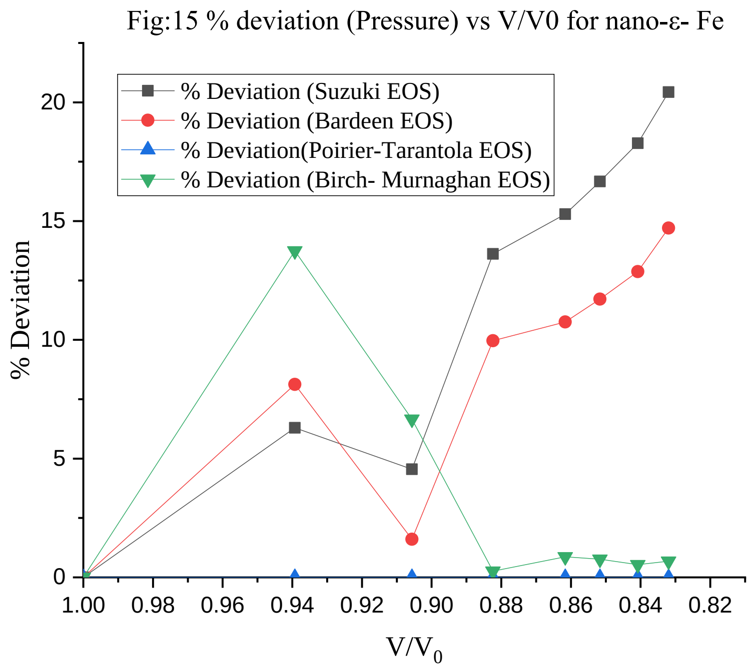

From figure (11-15) it is clear that the graph plotted between percentage deviation at various compressions. We have employed four different EOSs viz. Suzuki EOS, Bardeen EOS, Poirier-Tarantola EOS and Birch-Murnaghan EOS. We notice that the Birch-Murnaghan EOS calculated value very close to experimental value, therefore the Birch-Murnaghan EOS is best suitable for 37nm Al_2O_3 comparison to other three EOS. Further, the Poirier-Tarantola EOS and Birch-Murnaghan EOS calculated value very close to experimental value, therefore the

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Poirier-Tarantola EOS and Birch-Murnaghan EOS is best suitable for 67nm Al_2O_3, 3C-SiC and nano-Ni. Furthermore, The Poirier-Tarantola EOS is best suitable for nano-ε-Fe because its calculated value fully satisfied with experimental value.

Conclusion- The overall study of thermoelastic properties viz. Pressure and isothermal bulk modulus at high compression for 37nm Al_2O_3, 67nm Al_2O_3, 3C-SiC, nano-Ni and nano-ε-Fe nanomaterials lead to the conclusion that as pressure increases, compression value increases uniformly across all nanomaterials. It highlights that the Birch-Murnaghan EOS is best suitable for 37nm Al_2O_3. Additionally, both Poirier-Tarantola EOS and Birch-Murnaghan EOS are best suitable for 67nm Al_2O_3, 3C-SiC and nano-Ni nanomaterials throughout the range. However, for nano-ε-Fe exhibits excellent agreement with experimental value of pressure.

At high compression, increase isothermal bulk modulus for all five nanomaterials. However, there are discrepancies in the behavior of the equations of state (EOS) across different materials. For example, in the case of 37nm Al_2O_3 all four EOS do not coincide throughout the compression range. Conversely, for 67nm Al_2O_3, the Birch-Murnaghan EOS and Poirrier – Tarantola EOS demonstrate good agreement across the entire compression range. Similarly, in the case of

3C-SiC, Nano-Ni and nano-ε-Fe nanomaterials, the Birch- Murnaghan EOS and Poirrier – Tarantola exhibits excellent agreement throughout the entire range.

Author declaration-

Ethics approval- the author declare that the manuscript is authors own work and has never published elsewhere.

Competitive interest- The author has no competitive interest.

Data availability- No data was used in this research.

Declaration of Generative AI and AI- Assisted Technologies in Writing Process – During the preparation of this work the author(s) used Chat GPT in order to improve language. After this tool/ service, the author(s) reviewed and edited the content as needed and take (s) full responsibility for the content of the publication.

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