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Editorial: Syntheses under extreme conditions

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Editorial on the Research Topic
Syntheses under extreme conditions

"Extreme conditions" in chemistry greatly depend on the perspective. High temperatures, as commonly used in solid state chemistry may appear "extreme" to many chemists in other research areas, while a successful synthesis at room temperature of products previously only obtained at very high temperatures, might also be considered "extreme". This Research Topic is dedicated to synthesis conditions that are beyond of what is typically feasible with standard laboratory techniques. It emphasizes the fundamental necessity of developing novel methods, training students in these techniques, and a curiosity-driven exploration of "How far can we go?" These approaches open novel pathways to previously unknown compounds and/or modifications, ultimately expanding our profound understanding of matter.

Undoubtedly, high-pressure syntheses are considered "extreme" by most chemists, and were employed in the articles of this Research Topic. To synthesize $Dy_{36}O_{11}F_{50}[AsO_3]_{12}{\cdot}H_2O$ Schleid et al. followed an approach using suitable binary precursors in water at high-pressure conditions in gold ampoules. The structure comprises seven- and eightfold heteroleptic coordinated Dy^{3+} species, alongside $[AsO_3]^{3-}$ anions and crystal water trapped in large cavities.

Peña-Alvarez et al. report on the formation of sodium trihydride NaH_3 from the reaction of NaH at high hydrogen pressures of about 30, 40, 50, and 75 GPa in a diamond anvil cell. The findings are supported by Raman experiments and are compared to first principle calculations.

$NdRe_2$ was obtained by Hussein, Chuvashova et al. in the cubic $MgCu_2$ structure type from reactions at high-pressure high-temperature conditions in a diamond anvil cell. The results illustrate the formation of Laves phase structures at such special conditions, and the authors discuss connections to nuclear waste materials.

Via a high-pressure high-temperature reaction within a diamond anvil cell, the novel lanthanum hydroxyborate $La_2B_2O_5(OH)_2$ was obtained. The structure comprises discrete $[BO_3]$-units and three crystallographically independent lanthanum positions: one in ninefold, one in tenfold and one in twelvefold coordination, respectively. Besides the synthesis and the crystal structure, the authors Ibragimova, Chuvashova et al. estimated the band gap by *ab initio* calculations at different pressure points and discuss a possible use as a deep-ultraviolet birefringent material.

Two perovskite related silicates, $Fe_{0.5}Mg_{0.5}Al_{0.5}Si_{0.5}O_3$ and $FeMg_{0.5}Si_{0.5}O_3$ are reported by Koemets et al., which belong to the bridgmanite mineral class, comprising the most abundant minerals in the Earth's lower mantle. The authors observed a spin transition for Fe^{3+} in the iron rich phase at pressures higher than 40 GPa.

Glazyrin et al. report on the synthesis of orthorhombic BiN (space group *Pbcn*) from the reaction of the two pnictogens bismuth and nitrogen at pressures above 40 GPa. Furthermore, the authors studied the phase transition and compressibility of the phases during decompression. *Ab initio* calculations were performed to support the characterization of the different BiN polymorphs.

Spektor et al. report on the impact of pressure in the ternary Na-Si-H system by computational structure prediction and *in situ* synchrotron diffraction studies. Various hypervalent hydridosilicate phases $Na_mSiH_{(4+m)}$ (m = 1–3) at comparatively low pressures of 0–20 GPa are expected, which could potentially be interesting in terms of superconductivity, ion conductivity, and hydrogen storage.

Investigations on the Dy-C system by Akbar et al. reveal the novel compounds Dy_4C_3 and Dy_3C_2, obtained in a laser-heated diamond anvil cell by means of *in situ* single-crystal synchrotron X-ray diffraction. The corresponding sesquicarbide, Dy_2C_3, previously only known at ambient conditions, can also be obtained at such drastic conditions.

All contributions of this Research Topic clearly demonstrate, how "extreme syntheses" can facilitate the formation of hitherto unknown compounds, enrich the structural chemistry in the whole range from seemingly simple binary phases to complex multinary materials, and expand our general knowledge and understanding of chemistry.

Author contributions

JB: Conceptualization, Visualization, Writing–original draft, Writing–review and editing. MB: Conceptualization, Visualization, Writing–original draft, Writing–review and editing. GH: Conceptualization, Visualization, Writing–original draft, Writing–review and editing. GT: Conceptualization, Visualization, Writing–original draft, Writing–review and editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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