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Yttrium and lanthanum doped bioglass

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The best material for bone regeneration is bioglass, in the manufacture of which the following composition can be used: 24,5% Na₂O, 24,5% CaO, 45% SiO₂, 6% P₂O₅. It is possible to change the material properties by varying the glass composition, taking into account the needs of a particular task [1, 2].

The following bioglass samples were synthesized for research: 60S (60% SiO₂, 36% CaO, 4% P₂O₅) and 45S5 (45% SiO₂, 24,5% Na₂O, 24,5% CaO, 6% P₂O₅). They show excellent characteristics in the restoration of bone tissue. Bioglass 60S, doped with La and Y, was synthesized by the sol-gel method to study the properties of such solutions.

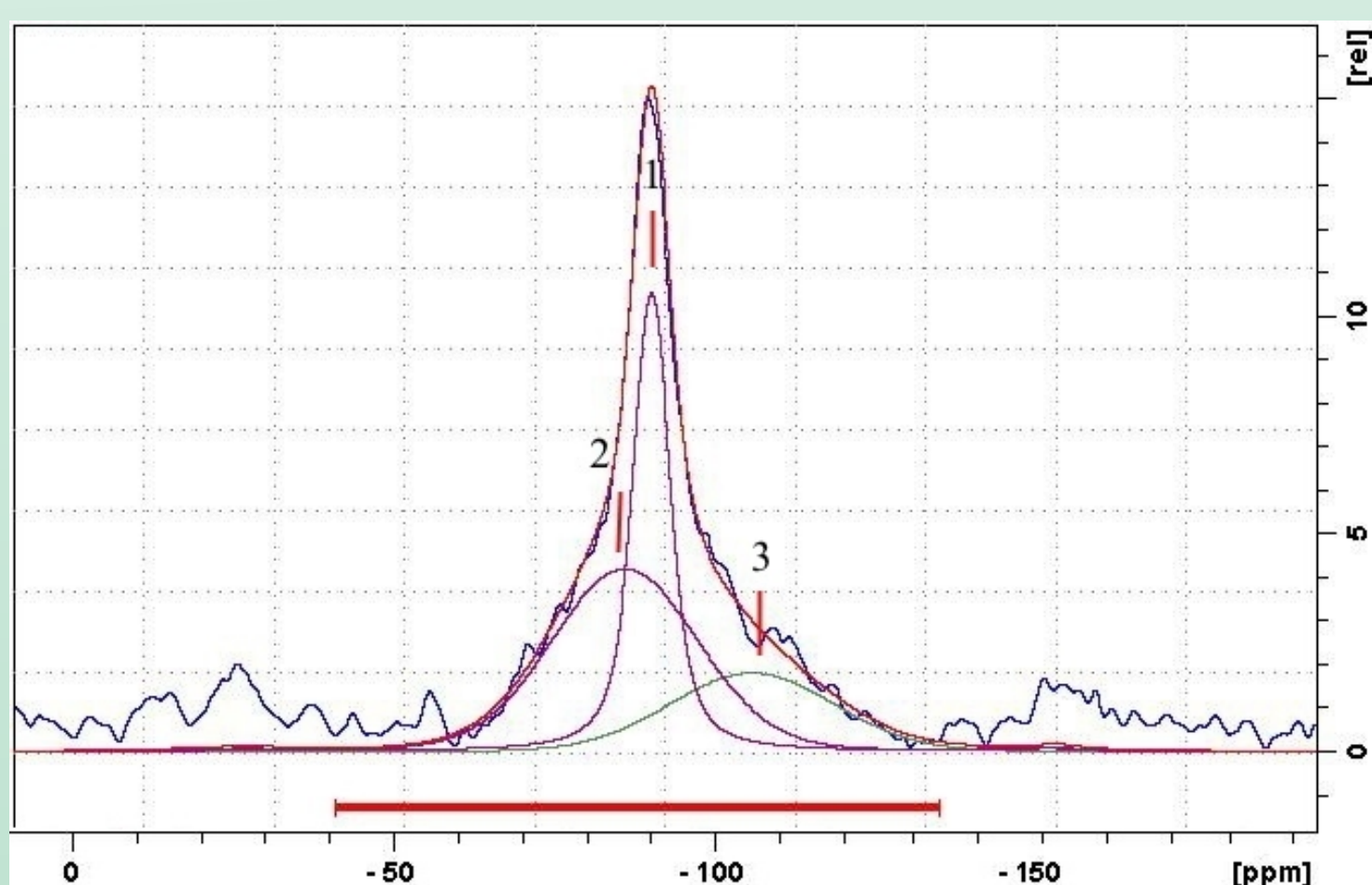


Fig. 1. ²⁹Si MAS NMR 45S5.

Structural features and electronic structure of bioactive glass, including yttrium and lanthanum doped ones, were studied using the method of nuclear magnetic resonance on the ²⁹Si and ³¹P nuclei. Solid state NMR spectra have been obtained for both static and rotated under magic angle (MAS) samples.

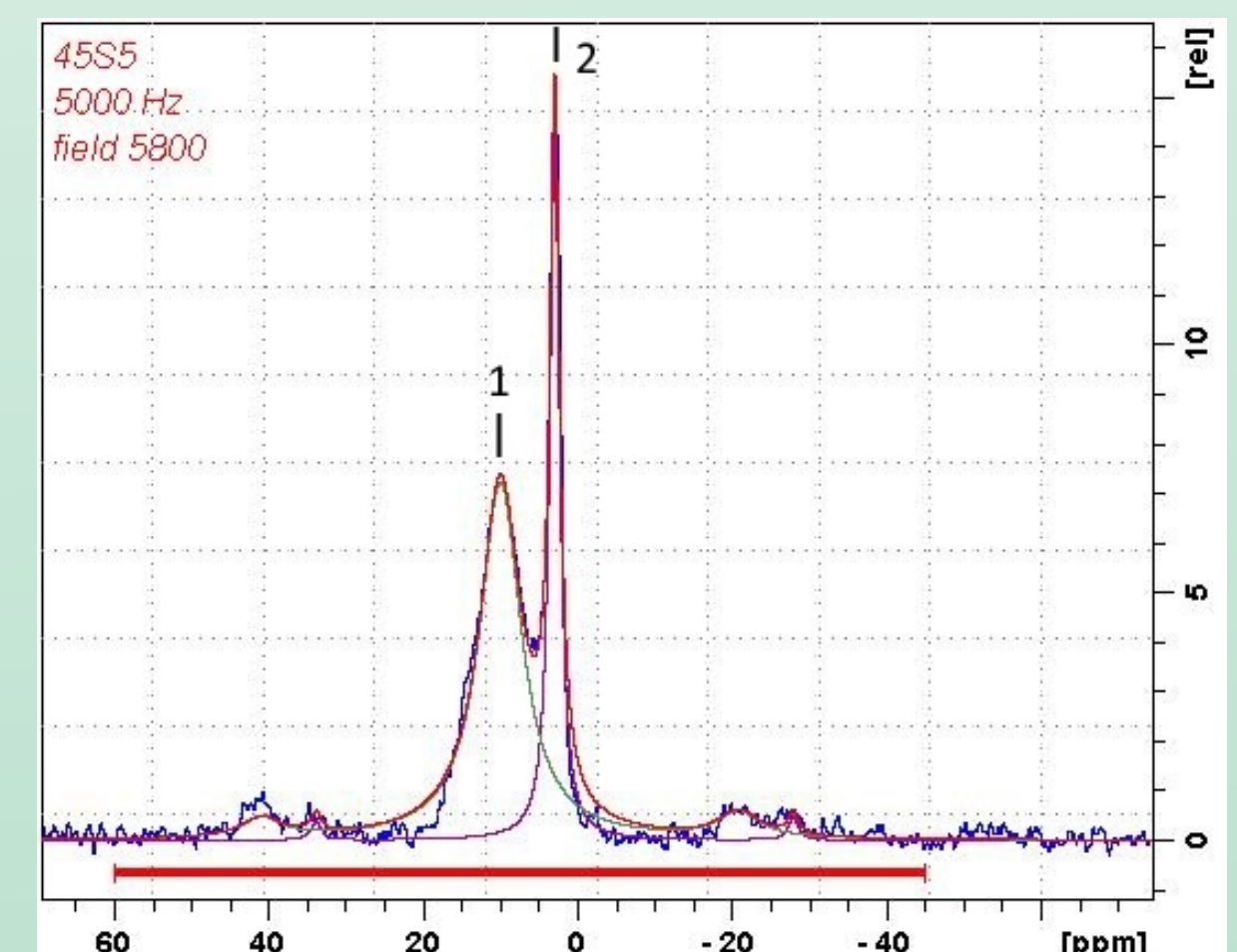


Fig. 2. ³¹P MAS NMR 45S5.

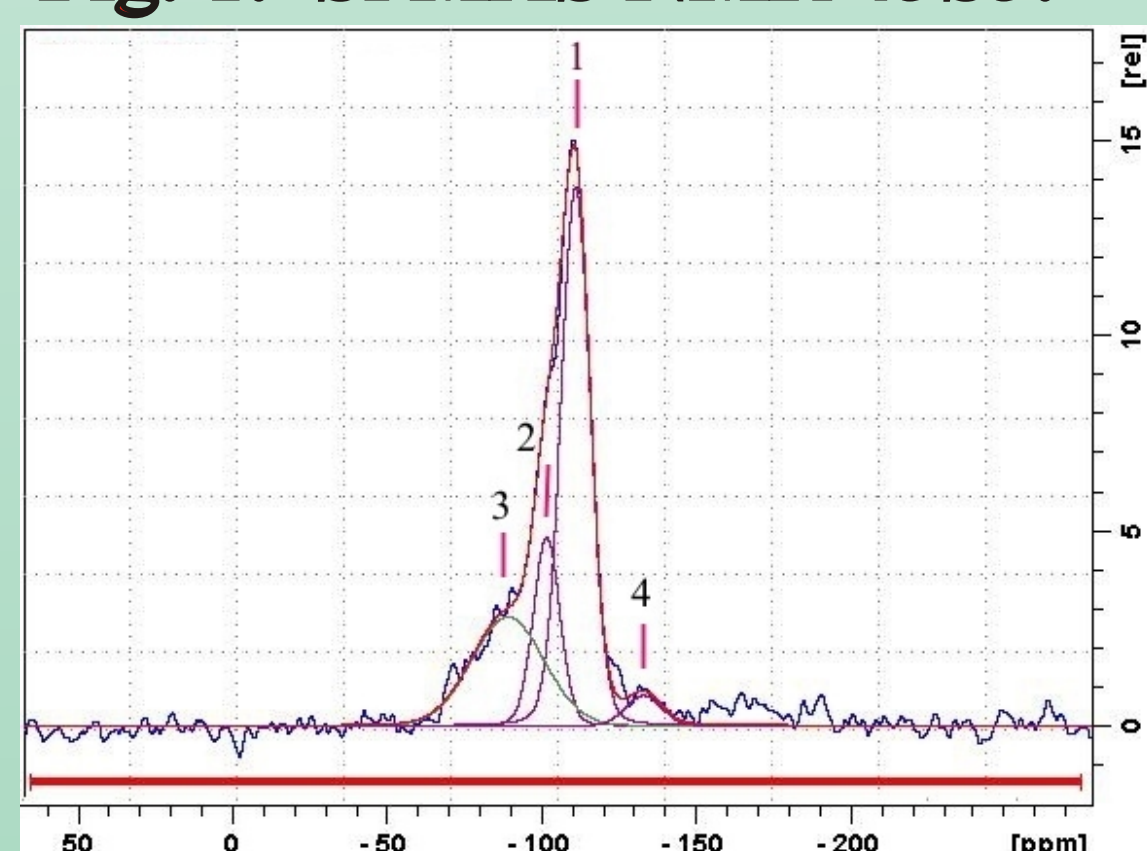


Fig. 3. ²⁹Si MAS NMR 60S, doped 2%La+2%Y.

NMR allowed identifying the presence and ratio of phosphate and silicate groups in a network-forming polyhedron, with a different number of bridging oxygens. Decomposition of NMR spectra into components indicates a different ratio of phosphate and silicate groups presented in these compounds, which depends on the synthesis conditions and initial components.

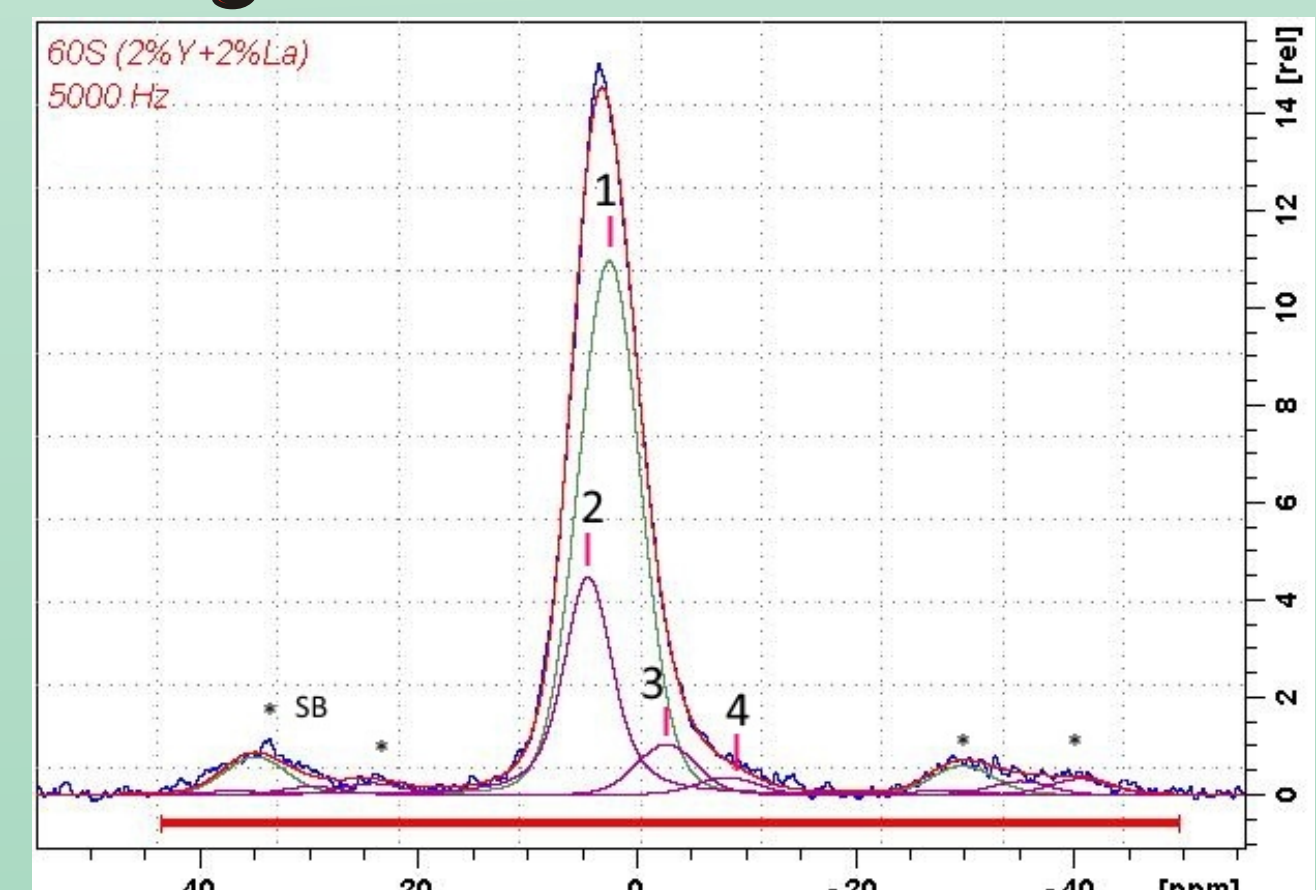


Fig. 4. ³¹P MAS NMR 60S, doped 2%La+2%Y.

According to the ²⁹Si MAS NMR spectrum of 45S5 bioglass (fig. 1), silicon in its structure is mainly presented in the form of SiO₄ tetrahedra connected to two other polyhedra through two bonding oxygens (line 2 ~ -85 ppm). Bioglass 45S5 is rich in phosphate phase, its ³¹P MAS NMR spectrum (fig. 2) mainly consists of (PO₄)³⁻ - line 1 around 10 ppm.

The main contribution to the ²⁹Si MAS NMR spectrum of 60S bioglass doped with La and Y comes from SiO₄ tetrahedra connected to four other polyhedra through four bonding oxygens (peak 1, Fig. 3). The ³¹P MAS NMR spectrum of this sample (fig. 4) is dominated by isolated PO₄ tetrahedra, while peak 4 on both spectra (based on its integral intensity) reflects the bonds with yttrium and lanthanum.

CONCLUSIONS

Bioglass doped with yttrium and lanthanum has a high therapeutic effect. Doping components are released due to material resorption in the form of ions, revealing their inherent biological properties.

REFERENCE

1. Souza L., Lopes J.H., Encarnação D., Mazali I.O., Martin R.A., Camilli J.A., Bertran C.A. Comprehensive in vitro and in vivo studies of novel melt-derived Nb-substituted 45S5 bioglass reveal its enhanced bioactive properties for bone healing // Scientific Reports.-2018.-8.-12808. DOI:10.1038/s41598-018-31114-0.
2. Araujo M.S., Silva A.C., Cabal B., Bartolome J.F., Mello-Castanho S. In vitro bioactivity and antibacterial capacity of 45S5 Bioglass®-based compositions containing alumina and strontium // Journal of Materials Research and Technology.-2021.-P.154-161.