From the apatite formation time (bioactivity) for the 70 glasses selected for the mixture design, the following model equation is obtained:

$$\begin{aligned}\text{Bioactivity} = &-39.97\cdot X_1 - 141.64\cdot X_2 - 243.35\cdot X_3 \\ &- 7290.43\cdot X_4 - 2525.93\cdot X_5 + 369.97\cdot X_1X_2 \\ &+ 572.87\cdot X_1X_3 + 14,436.04\cdot X_1X_4 + 4826.36\cdot X_1X_5 \\ &+ 1350.90\cdot X_2X_3 + 12,875.76\cdot X_2X_4 + 6197.23\cdot X_2X_5 \\ &+ 12,880.77\cdot X_3X_4 + 9990.18\cdot X_3X_5 + 71,120.91\cdot X_4X_5 \\ &- 2548.93\cdot X_1X_2X_3 - 24,007,82\cdot X_1X_2\boldsymbol{X}_4 - 11,195.21\cdot X_1X_2X_5 \\ &- 23,470.61\cdot X_1X_3X_4 - 19,382.06\cdot X_1X_3X_5 - 130,904,06\cdot X_1X_4X_5 \\ &+ 7867.29\cdot X_2X_3X_4 - 28,301.43\cdot X_2X_3X_5 - 69,149.45\cdot \boldsymbol{X}_2X_4X_5 \\ &- 82,201.72\cdot X_3X_4X_5 - 29,121.33\cdot X_1X_2X_3X_4 + 60,897.77\cdot X_1X_2\boldsymbol{X}_3X_5 \\ &+ 84,095.13\cdot X_1X_2X_4X_5 + 102,032.32\cdot X_1X_3X_4X_5 \\ &- 433,002.90\cdot X_2\boldsymbol{X}_3X_4X_5 + 1,101,722.08\cdot X_1X_2X_3X_4X_5\end{aligned}$$

Comparing the experimental results and the values predicted by the formula for the verification glasses confirmed the validity of the model. Eventually, the isobioactivity curves can be plotted from the *Bioactivity=f* (Xi) equation, highlighting the different domains of bioactivity within the study area. These domains are presented in Fig. 3.10A–I.

Overall, the study of these domains shows that there are glasses developing HCA in <5 h in the ternary system SiO_2-CaO-Na_2O (Fig. 3.10A). In order to keep compositions able to develop HCA in <5 h, it is necessary to incorporate >2.5% of P_2O_5 (Fig. 3.10C). The fluoride ion slows the formation of apatite, but a high phosphorus ratio helps to mitigate this negative impact of F^- (Fig. 3.10G, H, and I).

Other parameters have been studied using the mixture design method: the melting temperature of the powder mixtures, the glass transition temperature (Tg), the crystallization temperature (Tc), the working range, i.e., the difference between crystallization and glass transition temperatures, the density of glasses, and the thickness of HCA formed on the surface of glasses.

3.4 IMPROVEMENT OF THE MECHANICAL PROPERTIES OF BIOACTIVE GLASSES BY DOPING WITH NITROGEN

3.4.1 Overview

Knowledge of the physicochemical properties of biomaterials is essential in the design of bone implants. Biomaterials must be nontoxic, chemically inert, or bioactive, i.e., creating a chemical bond between the material and the living tissue. Their mechanical strength must also be sufficient, on the one hand, to be cut by the surgeon to a desired shape, on the other hand, to support forces exerted repetitively over a long time when they are introduced into the body.