α-TCP Cement: Establishing a Baseline

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Abstract. Establish a consistent α-TCP cement baseline before changing additives or particle size. This note defines liquid-to-powder ratios, gives an illustrative mixing matrix and sets out separate checks for handling and phase conversion. The proposed levels are screening conditions, not a validated formulation.

Keywords: α-TCP; calcium phosphate cement; liquid-to-powder ratio; setting

1. Separate reaction chemistry from workability

α-TCP can form a calcium-deficient apatite during aqueous setting. The overall idealized balance can be written as 3 $Ca_3(PO_4)_2 + H_2O = Ca_9(HPO_4)(PO_4)_5OH$. The reaction balance does not specify how fast the paste sets or how much mixing liquid is needed. Multicomponent α-TCP cements also respond to the liquid formulation and added solids [1].

Establish a powder-only identity check using XRD, a defined dispersion method for particle size and a recorded storage condition. Keep this powder constant while establishing the first mixing window. A paste that spreads well but separates under pressure is not an acceptable baseline for delivery.

Illustrative bench calculation: at L/P = 0.35 mL/g, a 10.00 g powder charge receives 3.50 mL liquid. If liquid density is 1.05 g/mL, this is 3.675 g liquid and P/L = 2.72 g/g, not 2.86. The levels below are proposed screening points around this example, not a validated formulation.

2. Establish the working window

2.1 Fix the time origin. Start the clock at first liquid contact. Use the same mixing duration, vessel, charge size and mixing motion. Record powder and liquid temperature before mixing. Test flow or extrusion at the same elapsed time, not when an operator feels the paste is ready.

Table 1. Development comparison and interpretation controls.

Screening point	Liquid for 10 g powder	Question to resolve
L/P 0.30 mL/g	3.00 mL	Can the powder wet fully?
L/P 0.35 mL/g	3.50 mL	Is handling repeatable?
L/P 0.40 mL/g	4.00 mL	Does excess liquid separate?
Repeat the center	Fresh independent mix	Is variation smaller than the effect?

2.2 Follow conversion and handling separately. Record initial and final set using the selected test method. Examine hardened phase composition at defined ages, with a consistent reaction-stopping procedure where required. Indentation resistance is a handling endpoint; it does not demonstrate complete chemical conversion.

2.3 Add one formulation function at a time. After choosing a workable L/P range, compare the baseline liquid with one defined modifier. Record the modifier concentration in the liquid and its mass relative to total powder. Keep a modifier-free control. Do not simultaneously change particle size, liquid salt concentration and polymer content.

3. Development decision

Retain the lowest-liquid candidate that can be mixed and handled consistently without unacceptable separation, then confirm wet strength and phase development. If handling remains unreliable, investigate dispersion before compensating with more liquid.

Scope. The numerical matrix is for laboratory screening. A final formulation requires application-specific handling, mechanical and biological evaluation.

References

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