Electronic Supplementary Information

Probing the Influence of Strontium Doping and Annealing Temperature on Structure and Biocompatibility of Hydroxyapatite Nanorods

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Table S1. Molar ratios of $Ca(NO_3)_2.4H_2O$, $Sr(NO_3)_2$, $(NH_4)_2HPO_4$ used in experiments, Ca/Sr ratio, chemical formula and abbreviations (M: molar; m: moles; g: grams).

Sr. No	$Ca(NO_3)_2$	$Sr(NO_3)_2$	$(NH_4)_2HPO_4$	Ca:Sr molar ratio	(Ca+Sr)/P molar ratio	Wt. % of Sr doping	Chemical formula	Sample designations
1	0.50 M	0.00 M	0.30 M	10:00	1.66	0	$Ca_{10}(PO_4)_6OH)_2$	HAp-UA, HAp-600, HAp-800
2	0.45 M	0.05 M	0.3 M	09:01	1.66	9.05%	$Ca_9Sr_1(PO_4)_6(OH)_2$	Sr1-UA, Sr1-600, Sr1-800
3	0.25 M	0.25 M	0.3 M	05:05	1.66	47.35%	$Ca_5Sr_5(PO_4)_6(OH)_2$	Sr5-UA, Sr5-600, Sr5-800
4	0.15 M	0.35 M	0.3 M	03:07	1.66	67.64%	$Ca_3Sr_7(PO_4)_6(OH)_2$	Sr7-UA, Sr7-600, Sr7-800
5	0	0.5 M	0.3 M	00:10	1.66	100%	$Sr_{10}(PO_4)_6 OH)_2$	Sr10-UA, Sr10-600, Sr10-800
6	0.46 M	0.04 M	0.3 M	9.2:0.8	1.66	7.22%	$Ca_{9.2}\ Sr_{0.8}(PO_4)_6(OH)_2$	Sr0.8-600
7	0.48 M	0.02 M	0.3 M	9.6:0.4	1.66	3.60%	$Ca_{9.6}.Sr_{0.4}(PO_4)_6(OH)_2$	Sr0.4-600
Unannealed- (UA) Annealing temperature-600 °C and 800 °C								

Table S2. Rietveld refinement data calculated using X'pert high score plus 4.7. ICDD numbers of different phases, unit cell parameters, unit cell volume and microstrains of various samples.

		Standard values from ICDD				After Rietveld Refinement					Crystallite Size measurement			
Sample	**ICDD**	**Chemical formula**	**a = b (Å)**	**c (Å)**	**Volume (Å)^3**	**a = b (Å)**	**c (Å)**	**Volume (Å)^3**	**Rwp**	**GoF**	**Microstrain (%)**	**Crystallite Size (Å)**	**Rwp**	**GoF**
HAp-UA	01-073-8419	$Ca_5(PO_4)_3(OH)$	9.4257	6.885	529.76	9.45173± 0.00667	6.89756± 0.003690	533.6±0.46	18.37	0.963	0.125±0.0094	306.9±0.59	18.68	0.977
HAp-600	01-073-8419	$Ca_5(PO_4)_3(OH)$	9.4257	6.885	529.76	9.41705± 0.00045	6.8850027 ±0.000225	528.58±0.03	6.982	2.098	0.16±0.00539	368.9±5.47	6.734	2.023
HAp-800	01-073-8419	$Ca_5(PO_4)_3(OH)$	9.4257	6.885	529.76	9.42143± 0.00071	6.8863± 0.000388	542.4±0.0047	5.524	1.63	0.108±0.0033	529.15±1.33	5.388	1.593
Sr1-UA	00-060-0648	$Ca_9Sr(PO_4)_6(OH)_2$	9.4706	6.923	537.77	9.4494± 0.01429	6.905± 0.007784	533.96±1.00	17.47	0.94	0.194±0.0524	277±26.94	17.66	0.973
Sr1-600	00-060-0648	$Ca_9Sr(PO_4)_6(OH)_2$	9.4706	6.923	537.77	9.44403± 0.00226	6.9072± 0.001223	533.51±0.15	6.711	2.04	0.261±0.007	288.7±4.74	7.79	2.37
Sr1-800	00-060-0648	$Ca_9Sr(PO_4)_6(OH)_2$	9.4706	6.923	537.77	9.45326± 0.00113	6.91215± 0.000622	534.94±0.08	7.801	2.38	0.061±0.008	404.8±5.03	6.7	2.04
Sr5-UA	00-034-0483	$Ca_8Sr_2(PO_4)_6(OH)_2$	9.486	6.951	541.68	9.51184± 0.01672	6.9826± 0.009351	547.14±1.20	15.09	0.909	0.397±0.057	383.3±85.5	15.57	0.933
	01-080-9970	$Sr_{10}(PO_4)_6(OH)_2$	9.7643	7.28	601.13	9.7643± 0.01877	7.2304± 0.011001	598.05±1.46	15.09	0.909	0.314±0.077	269.2±44.7	15.57	0.933
Sr5-600	00-034-0483	$Ca_8Sr_2(PO_4)_6(OH)_2$	9.486	6.951	541.68	9.5145± 0.00298	6.99± 0.001751	547.99±0.19	5.66	1.928	0.445±0.009	305.5±8.2	5.479	1.85
	01-080-9970	$Sr_{10}(PO_4)_6(OH)_2$	9.7643	7.28	601.13	9.7382± 0.00273	7.24± 0.00152	594.61±0.23	5.66	1.928	0.3±0.013	245.8±5.24	5.479	1.85
Sr5-800	00-034-0483	$Ca_8Sr_2(PO_4)_6(OH)_2$	9.486	6.951	541.68	9.5673± 0.00088	7.04644± 0.00535	558.57±0.06	6.871	2.3	0.3±0.0039	362.5±0.978	6.862	2.29
	01-080-9970	$Sr_{10}(PO_4)_6(OH)_2$	9.7643	7.28	601.13	9.6236± 0.00279	7.0952± 0.001742	569.08±0.21	6.871	2.3	0.77±0.00015	196.2±0.155	6.862	2.29
	01-085-7551	$Sr_7Ca_{3.5}(PO_4)_7$	10.662	38.94	3833.3	10.6515± 0.00118	38.7± 0.004132	3802.52±0.58	6.871	2.3	0.174±0.0008	429.9±1.631	6.862	2.29
Sr7-UA	01-080-9970	$Sr_{10}(PO_4)_6(OH)_2$	9.7643	7.28	601.13	9.6953± 0.00186	7.1787± 0.001028	584.39±0.13	6.83	2.91	0.348±0.0101	167.8±1.809	7.341	3.31

		Standard values from ICDD				After Rietveld Refinement					Crystallite Size measurement			
Sample	**ICDD**	**Chemical formula**	**a = b (Å)**	**c (Å)**	**Volume (Å)^3**	**a = b (Å)**	**c (Å)**	**Volume (Å)^3**	**Rwp**	**GoF**	**Microstrain (%)**	**Crystallite Size (Å)**	**Rwp**	**GoF**
	01-085-7551	$Sr_7Ca_{3.5}(PO_4)_7$	10.662	38.94	3833.3	10.78± 0.00177	38.83± 0.004922	3910.08±0. 81	6.83	2.91	0.2±0.0102	806.6±67.51	7.341	3.31
Sr7-600	01-080-9970	$Sr_{10}(PO_4)_6(OH)_2$	9.7643	7.28	601.13	9.6898± 0.00212	7.1751± 0.001188	583.43±0.1 6	6.07	2.78	0.406±0.0102	172.8±1.99	7.127	3.22
	01-085-7551	$Sr_7Ca_{3.5}(PO_4)_7$	10.662	38.94	3833.3	10.7075± 0.00194	39.0117± 0.005399	3873.54±0. 88	6.07	2.78	0.188±0.008	901.5±72.8	7.127	3.22
Sr7-800	01-085-7551	$Sr_7Ca_{3.5}(PO_4)_7$	10.662	38.94	3833.3	10.69± 0.0053	39.1± 0.001433	3876.92±0. 24	6.18	2.82	0.311±0.006	810.5±13.73	6.197	3.12
	01-080-9970	$Sr_{10}(PO_4)_6(OH)_2$	9.7643	7.28	601.13	9.64750± 0.00071	7.1508± 0.000433	576.39±0.0 5	6.18	2.82	0.071±0.003	295±4.98	6.197	3.12
Sr10-UA	01-080-9970	$Sr_{10}(PO_4)_6(OH)_2$	9.7643	7.28	601.13	9.77311± 0.00143	7.28155± 0.00913	602.3±0.11	15.48	1.019	0.076±0.01974	492.9±4.55	15.4	1.01
Sr10-600	01-080-9970	$Sr_{10}(PO_4)_6(OH)_2$	9.7643	7.28	601.13	9.77065± 0.00056	7.28194± 0.00315	602.03±0.0 4	6.843	2.411	0.117±0.0022	496.4±4.37	6.778	2.468
Sr10-800	01-080-9970	$Sr_{10}(PO_4)_6(OH)_2$	9.7643	7.28	601.13	9.77148± 0.00032	7.2836± 0.00185	602.27±0.0 2	7.218	2.16	0.043±0.0036	583.8±4.54	6.937	2.449
	01-073-4870	$Sr_3(PO_4)_2$	5.3917	19.8	498.42	5.39± 0.00019	19.79± 0.00626	498.16±0.0 2	7.218	2.16	0.046±0.0045	812.2±14.9	6.937	2.449

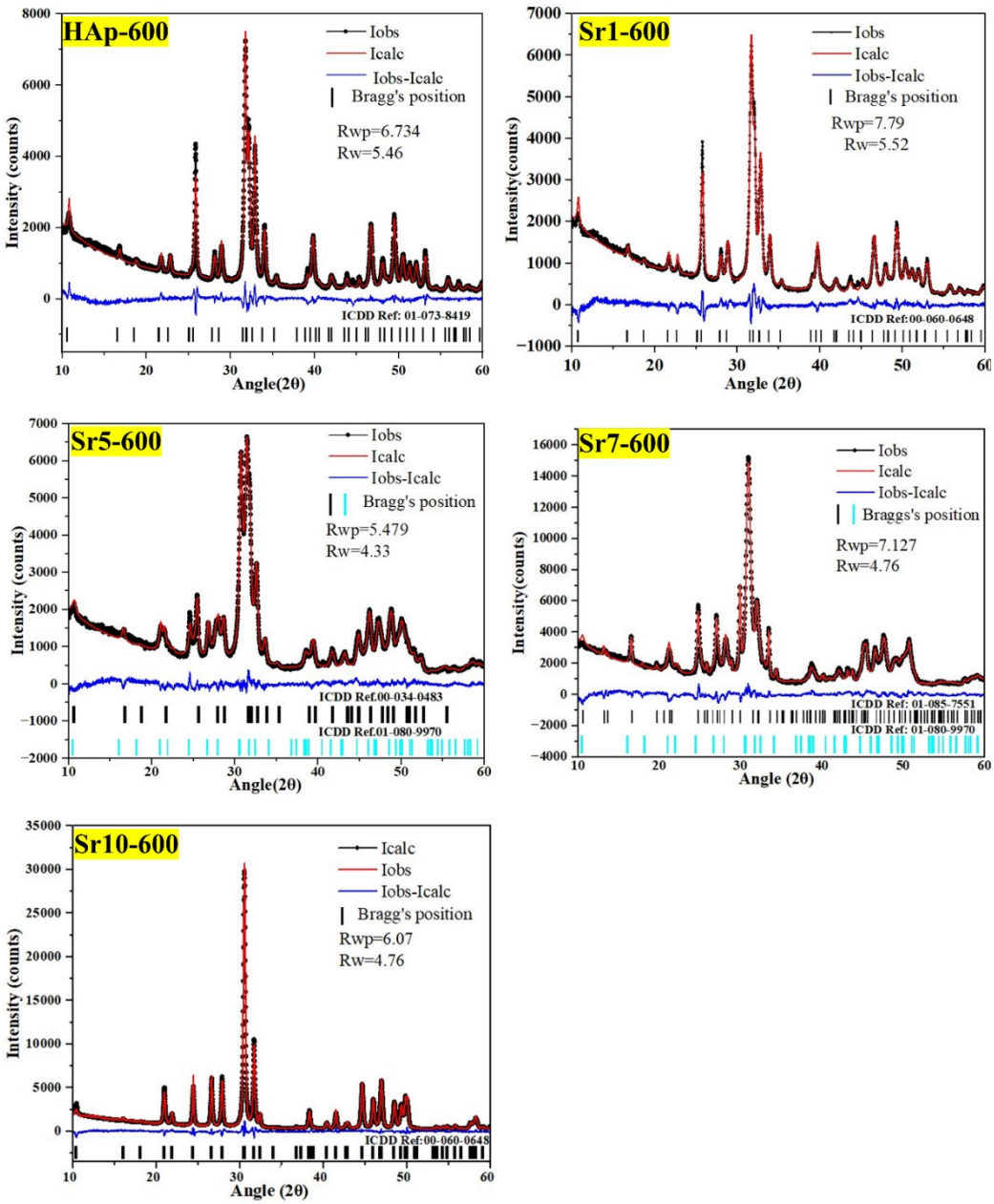

Fig. S1 Rietveld refinement plots of samples annealed at 600°C.

S 1. Measurement of average length, diameter and aspect ratio of the nanostructures

High magnification FESEM images were acquired at multiple locations for all the samples. The average length (L_{avg}) and average diameters (D_{avg}) were measured using Image-J 1.46r software. One such example is given below for the sample HAp-600. The yellow lines within the circles indicate length and diameters of the nanoparticles.

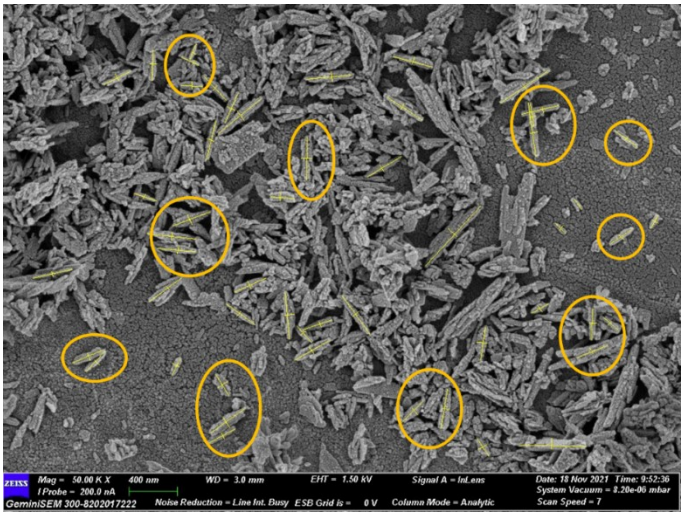

Fig. S2 Length and diameter measurement of the nanostructures.

Table S3. Average length, average diameter and aspect ratios of all the samples.

Samples	L_{avg} (nm)	D_{avg} (nm)	Aspect Ratio (L_{avg}/D_{avg})
HAp-UA	276.8±105	58.8±14	4.70±1.3
Sr1-UA	142.5±87	34.0±18	4.18±1.5
Sr5-UA	131.6±57	37.1±12	3.5±1.9
Sr7-UA	143.9±61	44.3±14	3.2±1.5
Sr10-UA	195.4±150	160.2±107	1.2±0.3
HAp-600	195.5±72	53.1±18	3.6±1.5
Sr1-600	224.2±78	56.0±18	4.0±1.7
Sr5-600	201.1±57	41.4±11	4.8±1.6
Sr7-600	144.6±62	44.4±14	3.2±1.2
Sr10-600	275.4±110	166.9±78	1.6±0.67
HAp-800	89.6±50	36.1±20	2.4±0.61
Sr1-800	253.8±83	93.3±26	2.7±0.69
Sr5-800	291.2±97	120.0±31	2.4±0.88
Sr7-800	285.0±124	167.9±60	1.6±0.58
Sr10-800	283.1±107	152.2±75	1.8±0.82

Table S4. Raman band positions, modes and assignments for Sr-HAp nanostructures annealed at UA, 600 °C and 800 °C.

Assignment	HAp-UA	Sr1-UA	Sr5-UA	Sr7-UA	Sr10-UA	HAp-600	Sr1-600	Sr5-600	Sr7-600	Sr10-600	HAp-800	Sr1-800	Sr5-800	Sr7-800	Sr10-800
Ca-PO_4	140	140	140	139	130	140	139	141	140	128	140	139	139	139	140
	205	205	198	197	193	205	208	198	169	191	209	203	184	185	191
	289	285	273	251	225	291	287	277	251	215	289	279	266	260	238
Ca-OH , v_3	329	328	316	315	315	334	330	324	320	317	330	332	319	319	314
PO_4^{3-} bend, v_2	431	431	428	423	422	431	430	426	424	424	431	430	423	423	417
PO_4^{3-} bend, v_4	592	591	588	585	581	592	591	588	587	580	592	592	586	585	606
	608	607	604	598	595	608	607	601	597	596	606	606	601	600	579
PO_4^{3-} sym. stretch,v_1	962	961	957	953	948	962	961	957	953	948	961	960	955	955	947
PO_4^{3-} Asym. stretching, v_3	1048	1047	1045	1039	1050	1048	1047	1042	1034	1051	1047	1046	1036	1032	1036
OH^- stretching mode	3573	3572	3576	3584	3593	3573	3573	3577	3590	3594	3573	3573	3583	3589	3593

S2. BET surface area analysis

The nitrogen adsorption/desorption analysis was performed to find the specific surface area of the samples (Sr-HAp samples annealed at 600°C) by Brunauer-Emmett-Teller (BET) method. the pore parameters (pore volume and pore radius) were evaluated from the desorption branch of isotherm based on Barrett–Joyner–Halenda (BJH) model using Autosorb IQ-XR, Anton Paar, Austria.

The detailed parameters of the pores dispersed on the nanoparticles (HAp-600 and its doped versions) were determined by N_2 adsorption method. Figure S2 shows the adsorption-desorption isotherms exhibiting the typical characteristics of a type IV curve with a hysteresis loop, signalling the mesoporous quality of Sr-HAp particles.[1] The values of pore volume and specific surface area (SSA) of nanoparticles are shown in table S5. From The highest and the lowest SSA were found to be 36.07 (m^2/g) and 25.22 (m^2/g) for HAp-600 and Sr10-600, respectively. It is important to note that as the dopant level increases in HAp, the surface area decreases. This might be due the change in the morphology from rod to sheet shape. In

addition, with the increase in the dopant level, both pore volume and pore radius increased until Sr5-600 and then decreased. This might be due to creation of defects within the sample.[2]

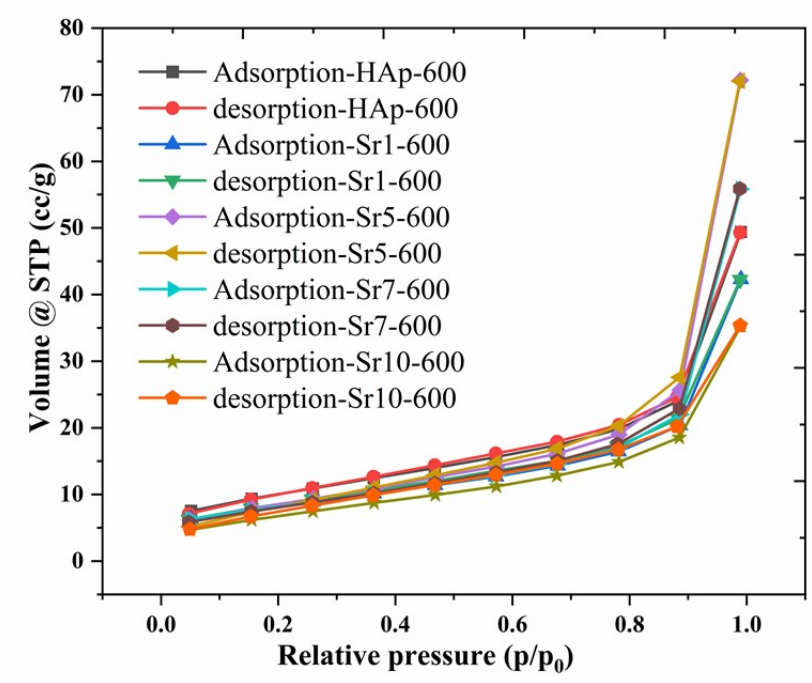

Fig. S3 Nitrogen adsorption–desorption isotherms of various Sr-HAp nanoparticles annealed at 600°C.

Table S5. Specific surface area, pore size and pore volume of various Sr-HAp nanoparticles annealed at 600°C.

	HAp-600	**Sr1-600**	**Sr5-600**	**Sr7-600**	**Sr10-600**
Average pore Radius (Å)	42.38	44.53	71.67	59.53	43.38
SSA (m^2/g)	36.07	29.40	31.16	29.02	25.23
Total pore volume (cc/g)	0.076	0.066	0.12	0.086	0.055

Table S6. Cell viability data.

Samples	2.5%	5%
Control	100	100
HAp-600	71	28
Sr0.4-600	88	75
Sr0.8-600	90	59
Sr1-600	87	26
Sr5-600	85	58
Sr7-600	71	66
Sr10-600	69	56

References

1. C. Shamitha, T. Senthil, L. Wu, B. S. Kumar and S. Anandhan, *J. Mater. Sci. Mater. Electron.*, 2017, **28**, 15846–15860.
2. H. Klym, I. Karbovnyk, A. Luchechko, Y. Kostiv, V. Pankratova and A. I. Popov, *Crystals*, 2021, **11**, 1515-1530.