Evaluation of Radiation Dose from Powder and Bulk Hydroxyapatite for Routine Dosimeter

Presented by

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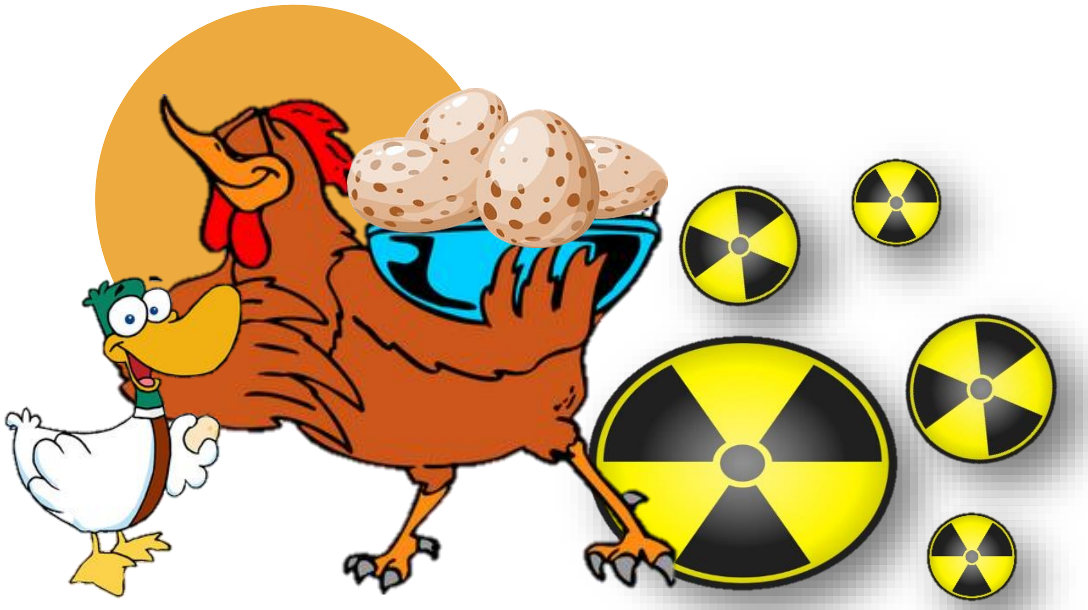
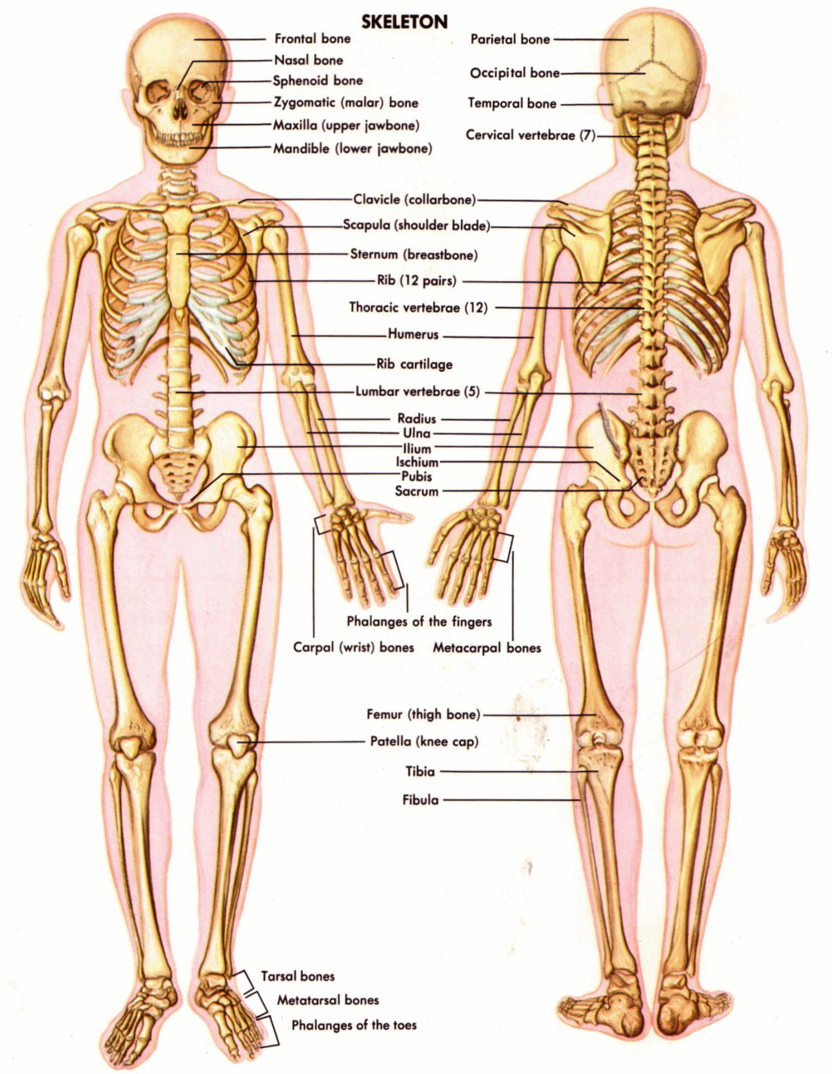


Outlines

- Introduction
- Objectives
- Experiment
- Results & Discussion
- Conclusions

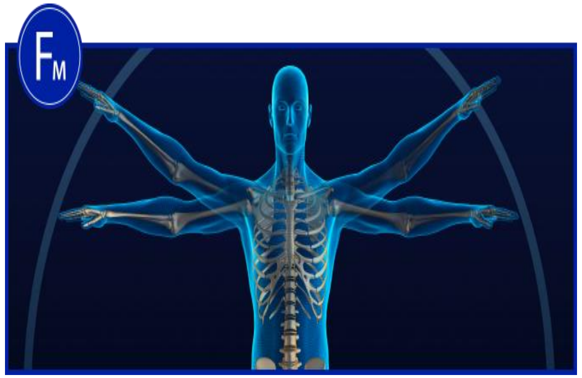
Introduction

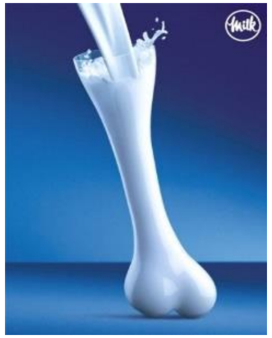


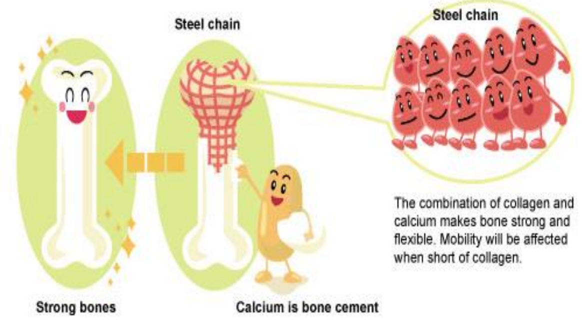
Ref : http://themissionlsc.com/human-skeleton-diagram.html

Functions of the bone

- ✓ Framework for support and movement
- ✓ Protection
- ✓ Storage of minerals
- ✓ Production of blood cells

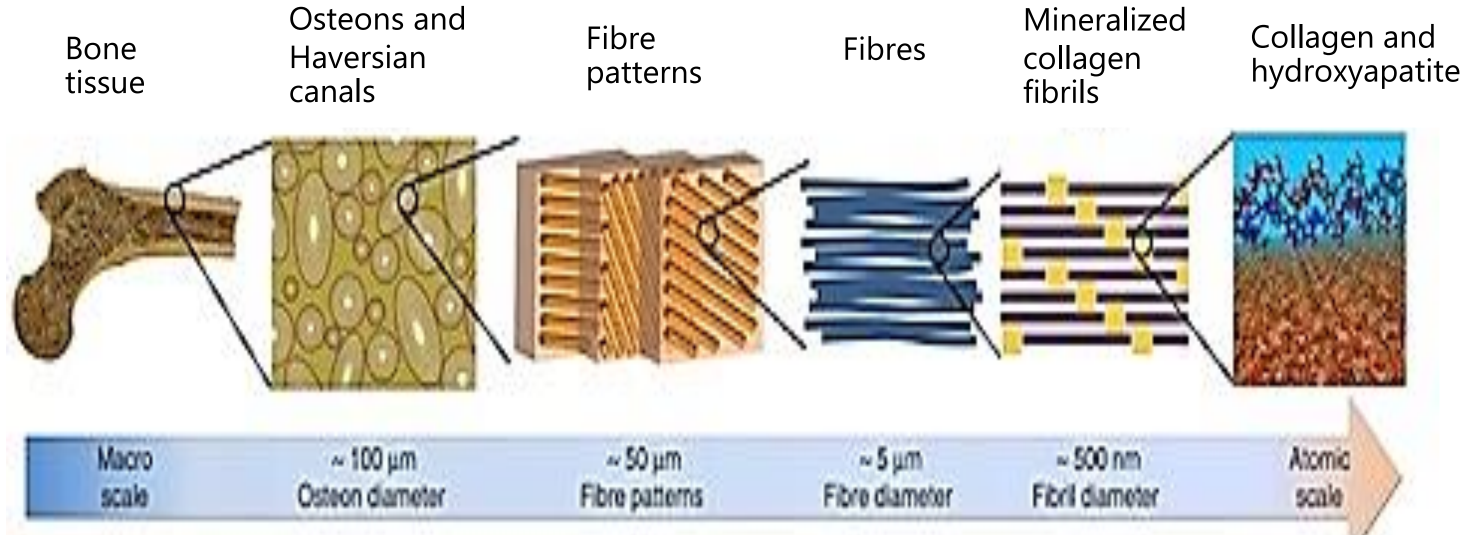




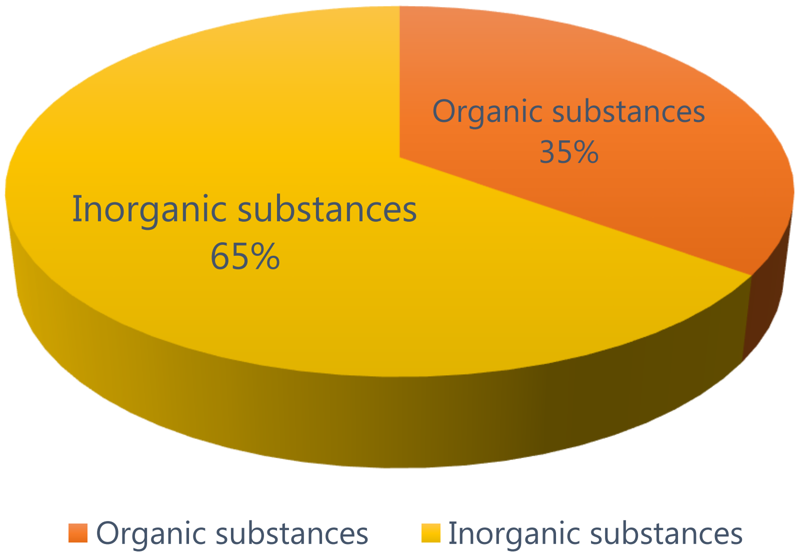


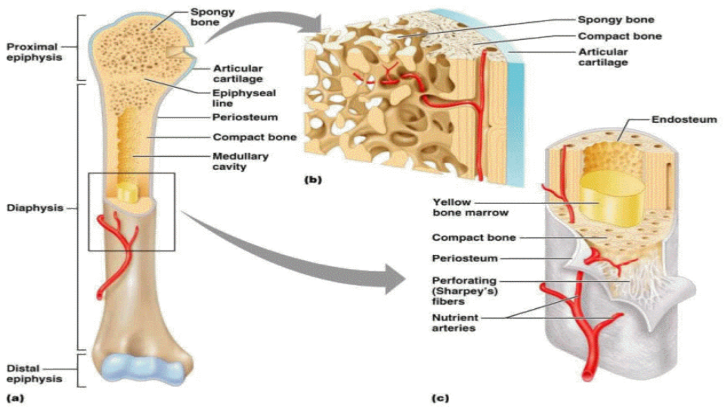
Introduction (cont.)

Composition of bone



Ref : http://txchnologist.com/post/54506899743





Bone structure

35% Organic

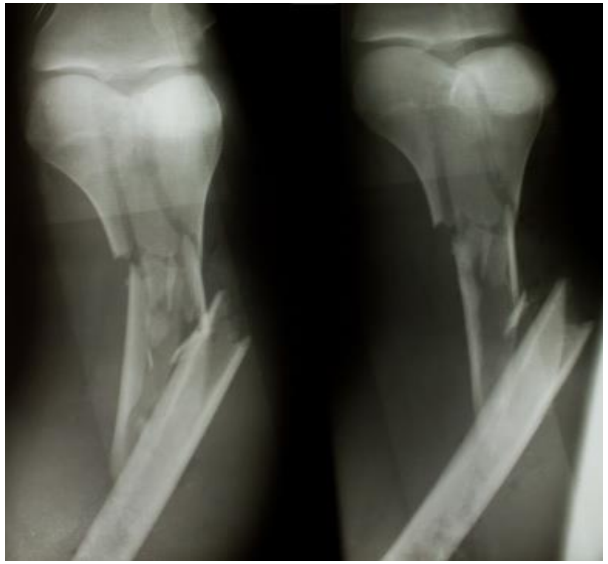
- ➢ 28% collagen
- ➢ 5% protein

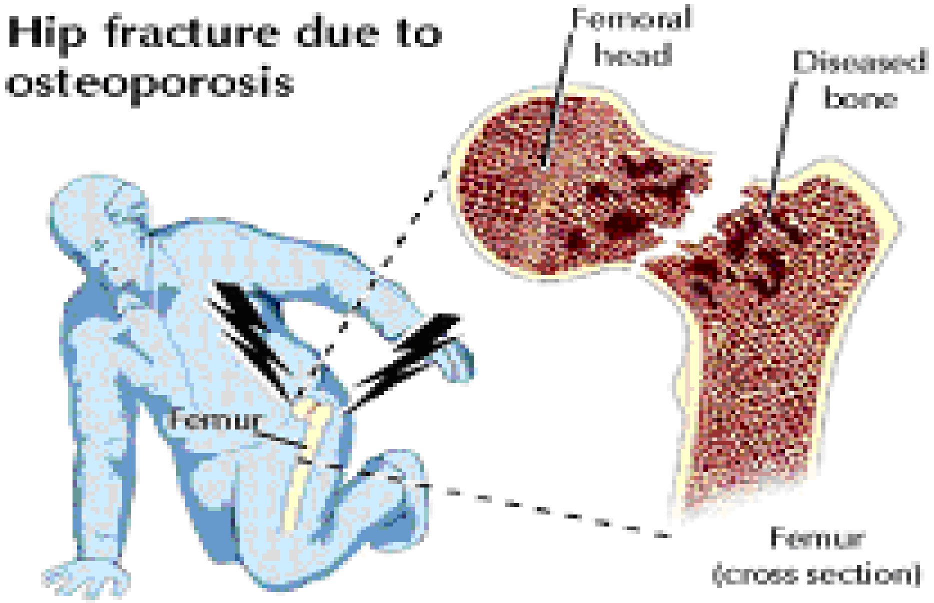
65% Inorganic (hydroxyapatite)
Mostly Calcium and inorganic orthophosphate deposited between collagen

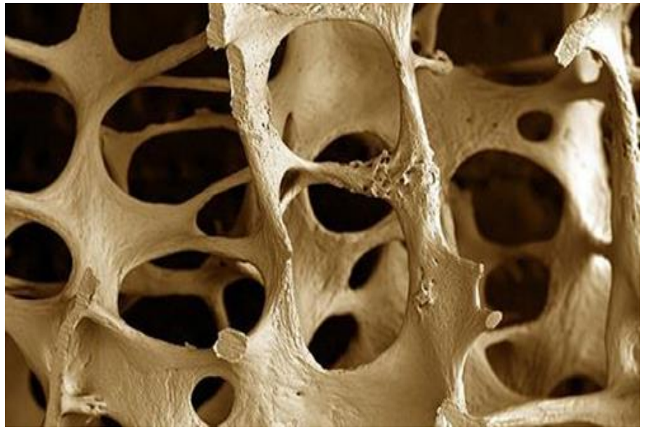
Calcium Phosphate

Introduction (cont.)

Bone fractures



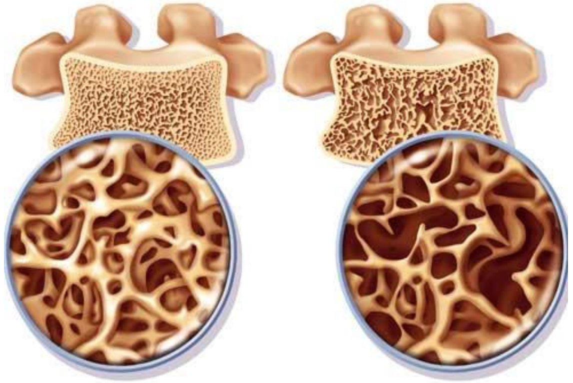




Types of fractures

1. Traumatic fracture (cause by an injury)
2. Spontaneous fracture (cause by a disease)

➡ **Osteoporosis**

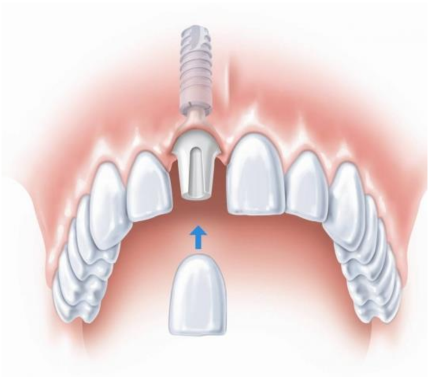


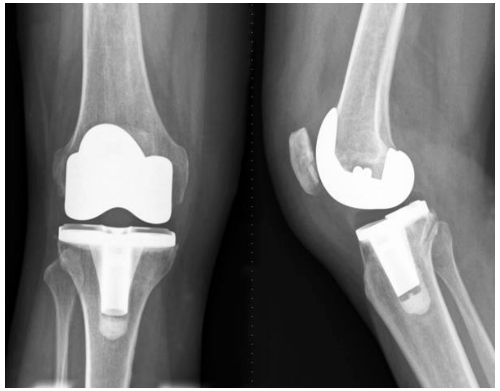
Introduction (cont.)

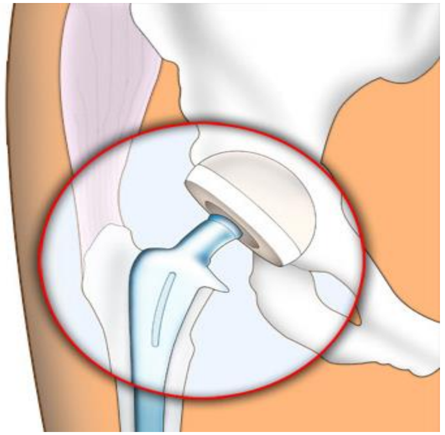
Calcium supplement

Glucosamine

Bone replacement material







Ref: http://tibordental.com

Bioceramic material

- Bioresorbable ceramic
- Bioinert ceramic
- Bioactive ceramic

"Hydroxyapatite"

Introduction (cont.)

Effect of radiation

In the future, the patients who had been treated with bone replacement with implanted bones from hydroxyapatite may be work about radiation or diagnose and radiotherapy by radiation. Then, hydroxyapatite from synthesis must be investigate the effect of radiation on hydroxyapatite.

Ref: http://www.telegraph.co.uk/news

Objectives

1. To study characteristic ESR signal on hydroxyapatite synthesized from quail eggshell before and after gamma irradiation.
2. To evaluate gamma radiation dose response on hydroxyapatite synthesized from quail eggshell.
3. To study fading time on hydroxyapatite synthesized from quail eggshell after irradiation.

SPC 2016
Siam Physics Congress 2016

Experiment : Sample Preparation

Samples preparation

Quail eggshell

Remove membrane, clean and crush into powder

Heat at temp. **1300** °C

$CaCO_3 \longrightarrow CaO + CO_2$

Sample:
Quail eggshell heated at 1300 °C (CaO)

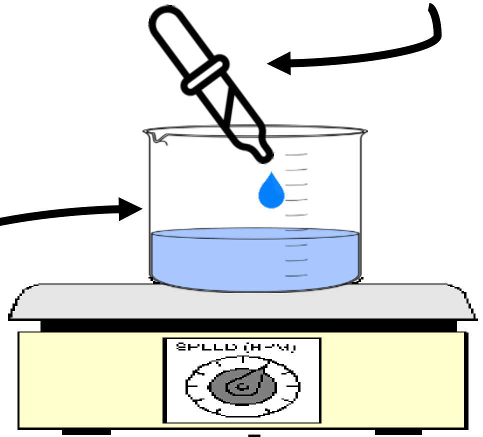
Hydroxyapatite synthesis

$CaO + HNO_3$

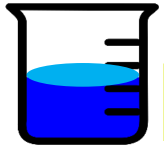
NH_4OH sol. — adjust pH → 6M $(NH_4)_2HPO_4$ sol.

adjust pH

10M $Ca(NO_3)_2$ sol.

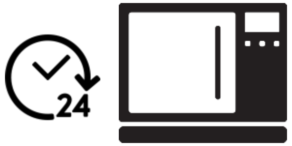


Precipitated



Keep at room temp. for 8 hr.

Filtered



Dry at 100°C 48 hr.

Ground into powder

Hydroxyapatite powder

Experiment : Characterization

Hydroxyapatite

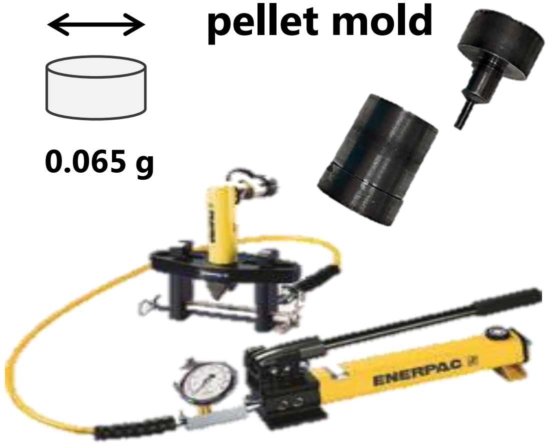
- Quail eggshell hydroxyapatite **(QS-HAp)**

Electron spin resonance spectroscopy

0.5 cm

0.065 g

pellet mold



Hydraulic hand pump

Irradiation

Gamma ray

Varies dose 0.1 – 10.0 kGy

Results

- **Characteristic of ESR signal**

Ionizing Radiation - induced free radicals

Results

- **Dose response**
- **Fading time**

post-irradiation fading affects the attainment of high accuracy in dosimetry measurements

Results & discussion

Characteristic ESR signal of HAp

Part 1-1 : Hydroxyapatite

QS-HAp

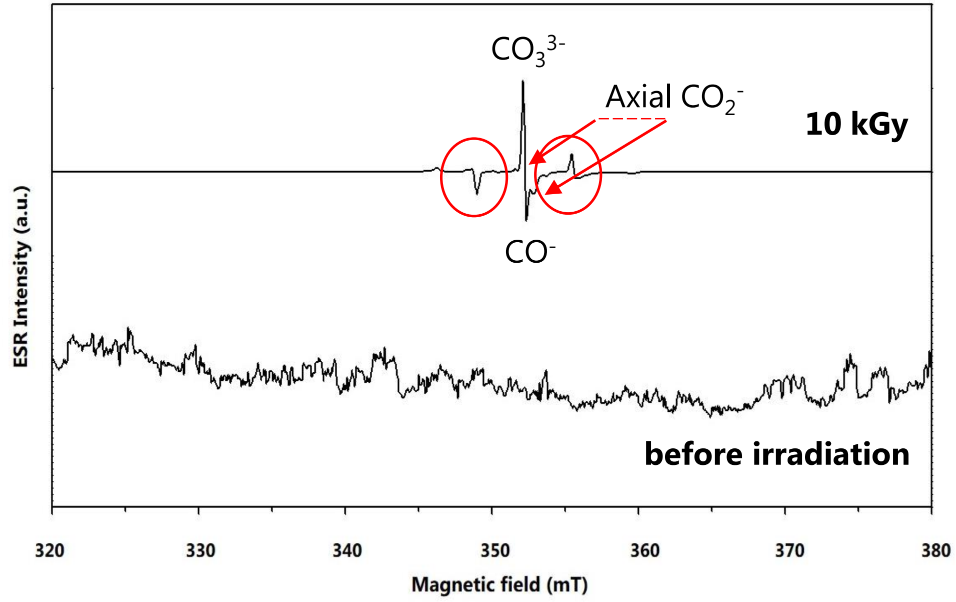


Fig.1 ESR signal QS-HAp before and after gamma irradiation

g - value	Free radical
2.0027± 0.0002	CO^-
2.0020± 0.0002	Axial CO_2^-
2.0016± 0.0001	CO_3^{3-}
1.9987± 0.0001	Axial CO_2^-

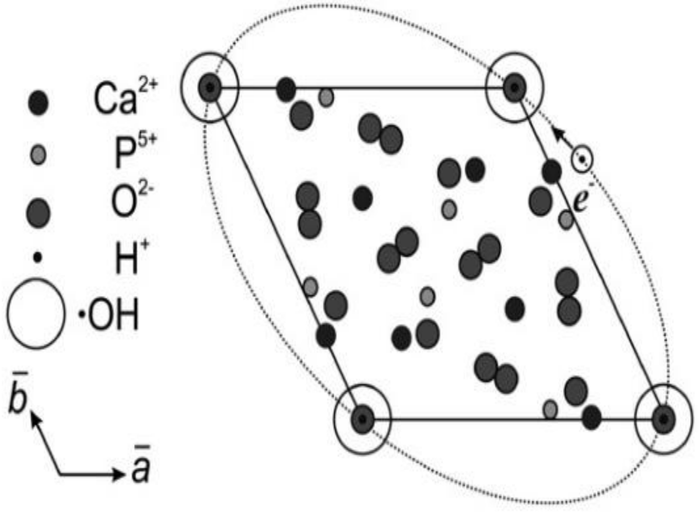


Fig.2 The model of paramagnetic center in HAp (Rokhmistrov, D.V. et al.,2012)

The new paramagnetic center in HAp was found. Its formation is assigned to the features of HAp synthesis in the aqueous solution, the free electron of HAp that formed by gamma irradiation interacts with the four photons of the four water molecules during its motion circular trajectory

Results & discussion (cont.)

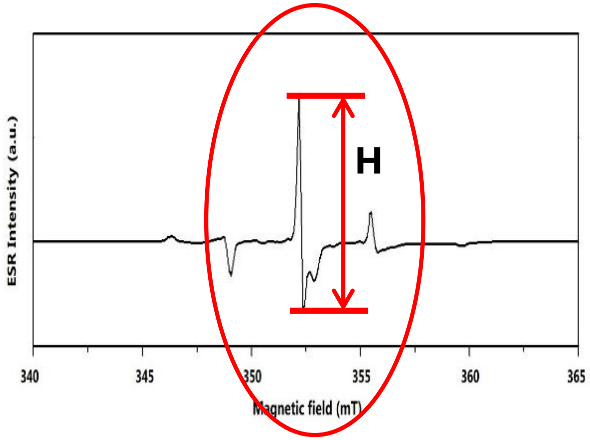
Dose response of hydroxyapatite

Part 2-1

Electron spin resonance spectroscopy

Table.1 Intensity of ESR signal on powder hydroxyapatite dose range 0.1 -10 kGy

Dose (kGy)	Intensity (a.u.)
0.1	149878.14
0.2	415871.08
0.4	786674.61
0.8	870261.05
1.0	1153782.04
2.0	2797915.03
4.0	5253393.26
8.0	8608628.43
10.0	10999885.25



Peak-to-peak intensity

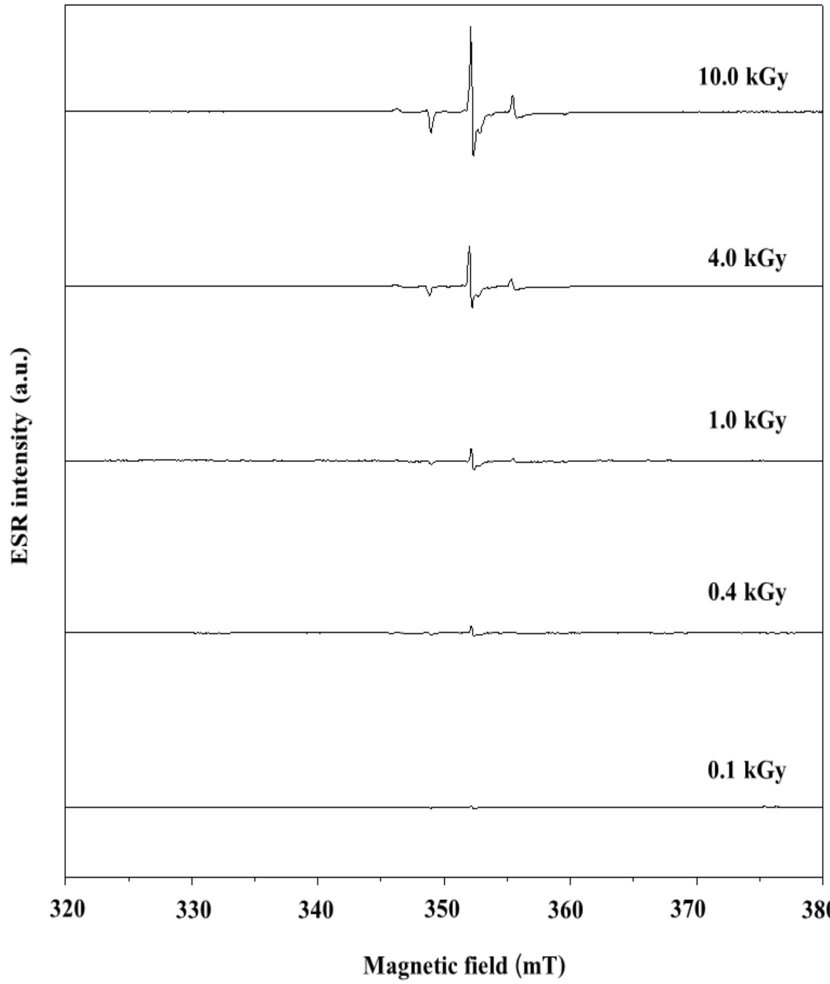


Fig.3 Effect of the radiation dose of powder QS-HAp irradiated with γ radiation at various dose

Results & discussion (cont.)

Dose response of hydroxyapatite

Part 2-1 : Powder QS-HAp (linear function.)

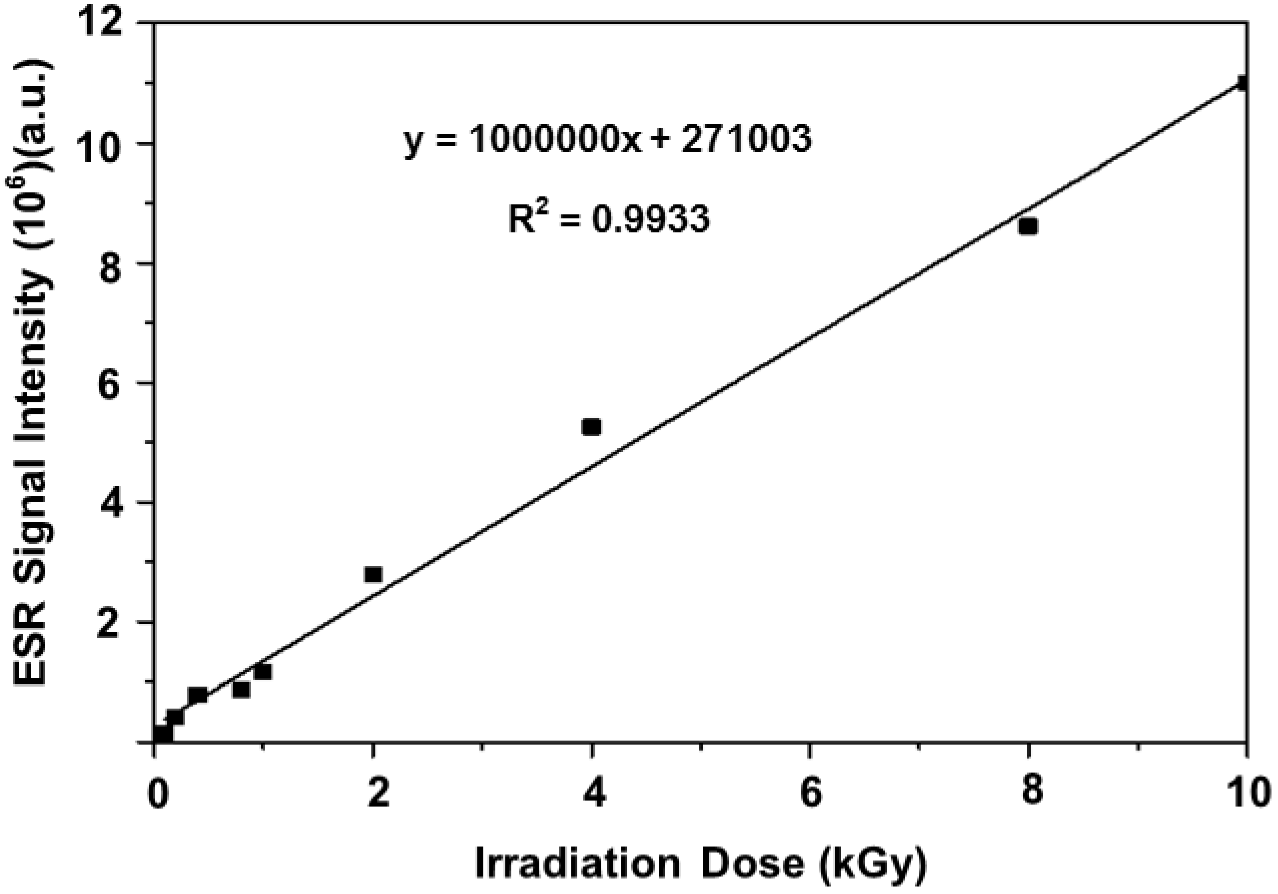


Fig.4 Dose response curve of powder QS-HAp irradiated with γ radiation at room temperature

Table 2. Comparison of radiation dose of powder QS-HAp

Irradiation dose (kGy)	Dose from calibration curve (kGy)	%error
0.1	-0.121	-
0.2	0.145	27.566
0.4	0.516	28.918
0.8	0.599	25.093
1.0	0.883	11.722
2.0	2.527	26.346
4.0	4.982	24.560
8.0	8.338	4.220
10.0	10.729	7.289

Results & discussion (cont.)

Dose response of hydroxyapatite

Part 2-2

Bulk QS-HAp

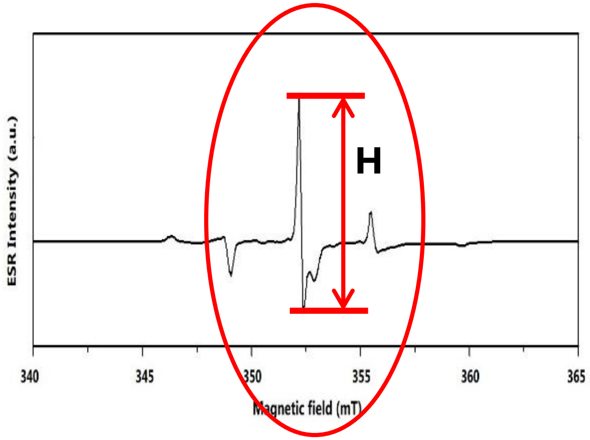
Gamma ray

Varies dose 0.1 – 10 kGy

Electron spin resonance spectroscopy

Table.3 Intensity of ESR signal on bulk hydroxyapatite dose range 0.1 -10 kGy

Dose (kGy)	Intensity (a.u.)
0.1	191816.58
0.2	452538.87
0.4	743780.43
0.8	1469312.06
1.0	1573107.97
2.0	2944184.86
4.0	4601256.67
8.0	7003901.69
10.0	7989371.00



Peak-to-peak intensity

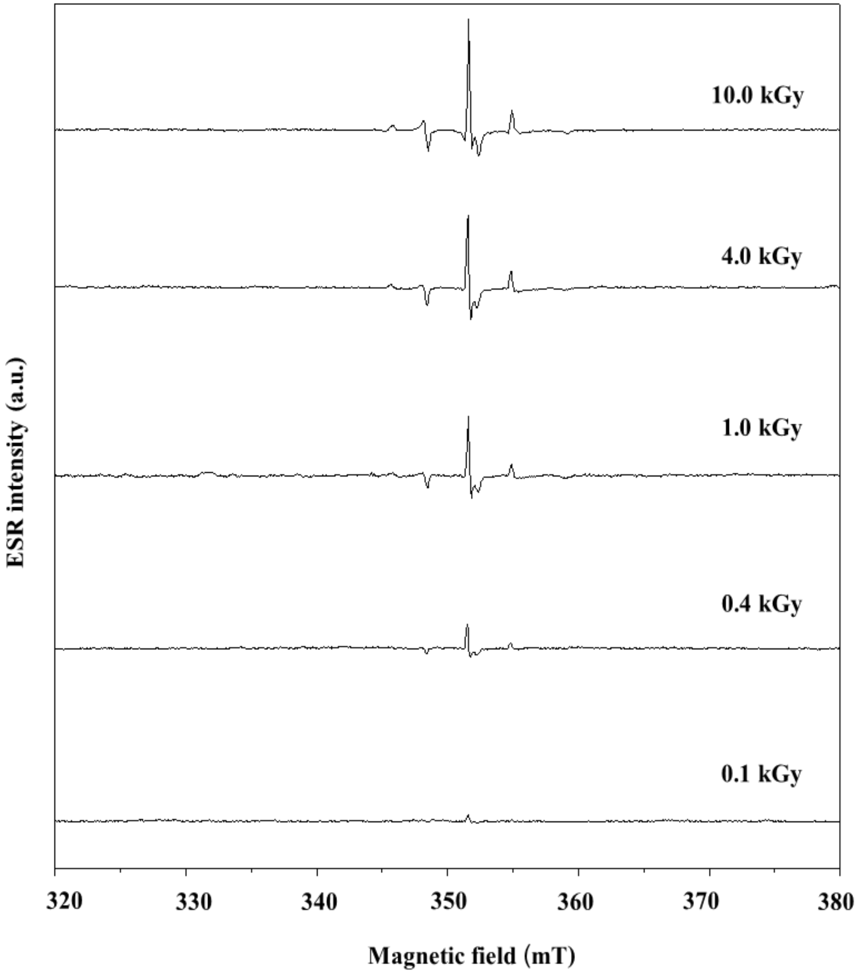


Fig.5 Effect of the radiation dose of bulk QS-HAp irradiated with γ radiation at various dose

Results & discussion (cont.)

Dose response of hydroxyapatite

Part 2-2 : Bulk QS-HAp (linear function.)

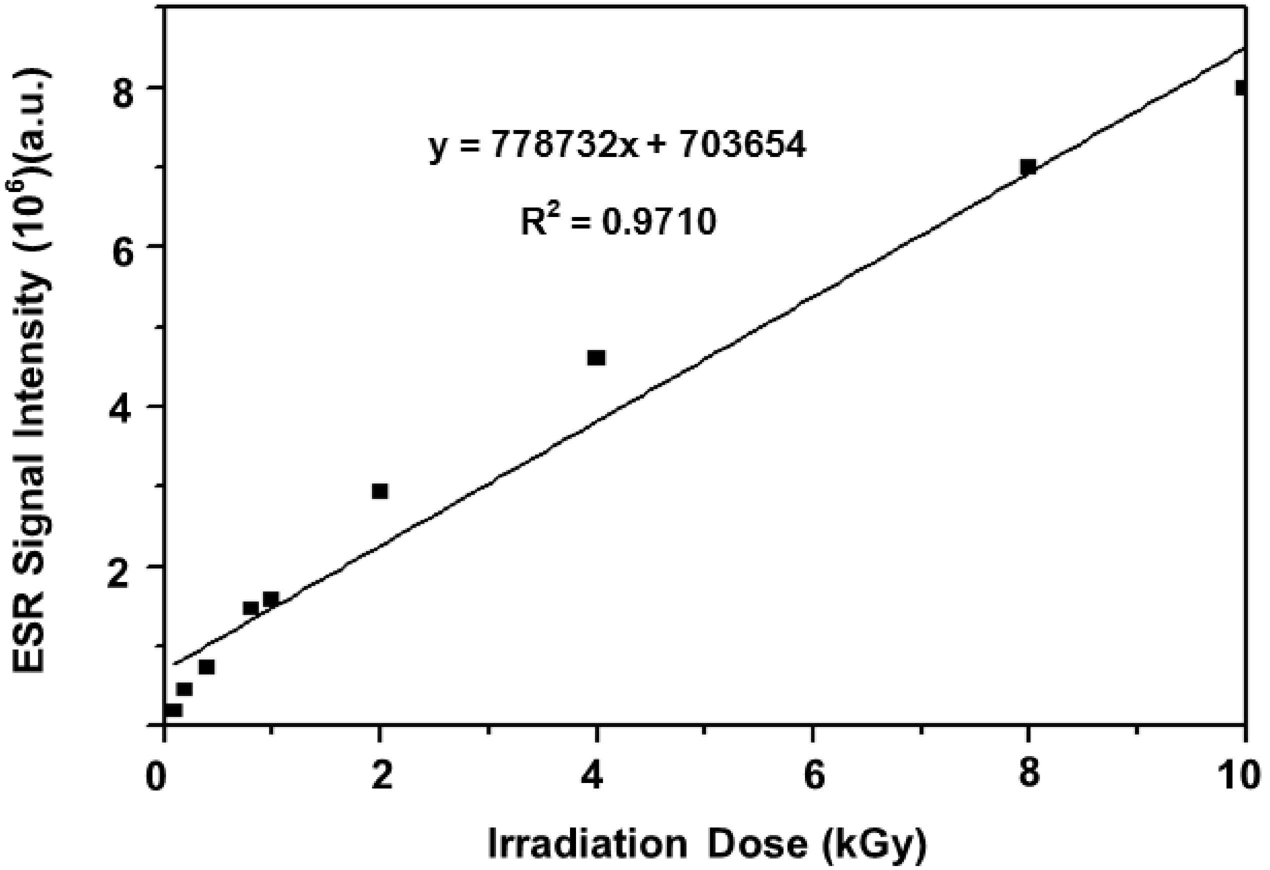


Fig.6 Dose response curve of bulk QS-HAp irradiated with γ radiation at room temperature (linear function)

Table 4. Comparison of radiation dose of bulk QS-HAp

Irradiation dose (kGy)	Dose from calibration curve (kGy)	%error
0.1	-0.657	-
0.2	-0.322	-
0.4	0.051	87.118
0.8	0.983	22.901
1.0	1.117	11.650
2.0	2.877	43.858
4.0	5.005	25.127
8.0	8.090	1.130
10.0	9.356	6.441

Results & discussion (cont.)

Dose response of hydroxyapatite

Part 2-2 : Bulk QS-HAp (polynomial function.)

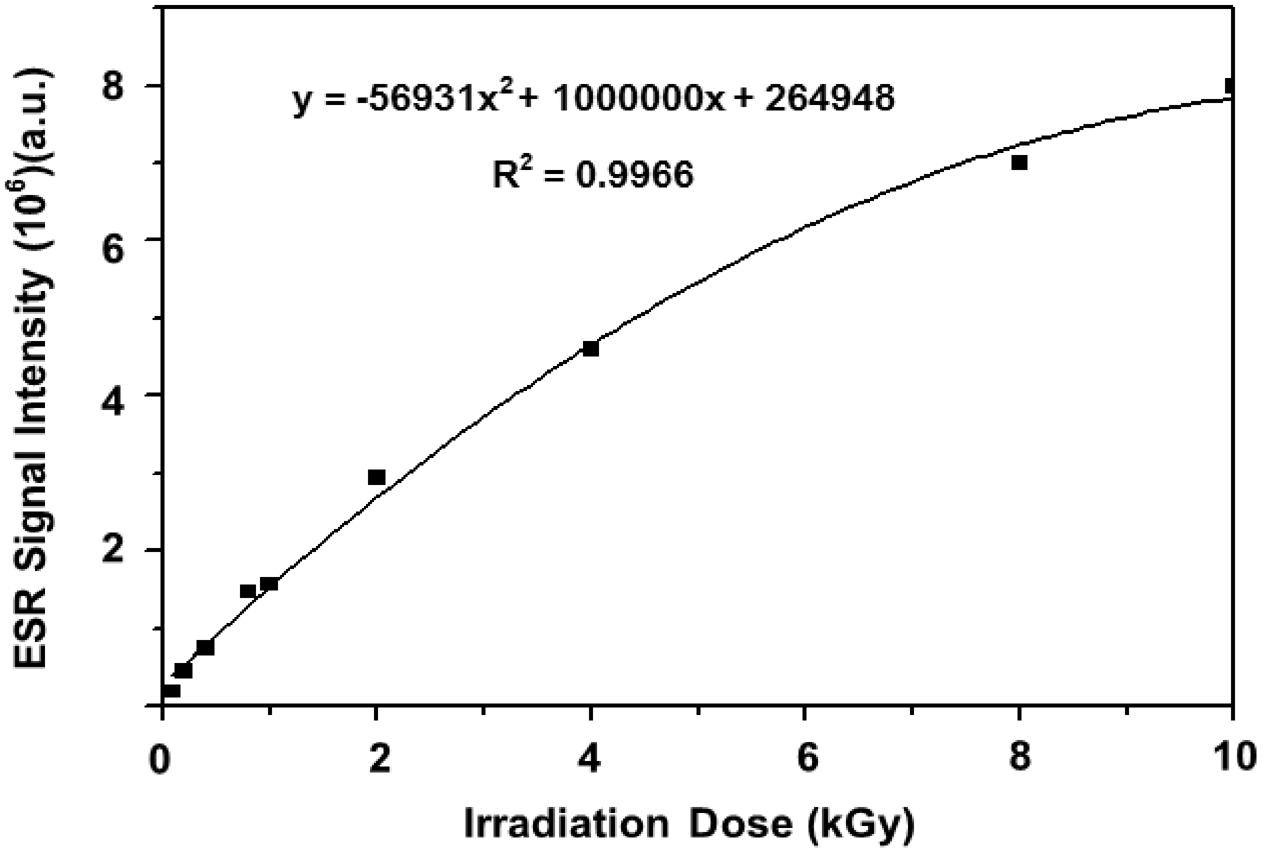


Fig.7 Dose response curve of bulk QS-HAp irradiated with γ radiation at room temperature (polynomial function)

Table 5. Comparison of radiation dose of bulk QS-HAp

Irradiation dose (kGy)	Dose from calibration curve (kGy)	%error
0.1	-0.073	-
0.2	0.190	5.181
0.4	0.493	23.162
0.8	1.301	62.585
1.0	1.424	42.353
2.0	3.299	64.937
4.0	7.800	94.998
8.0	-	-
10.0	-	-

Results & discussion (cont.)

Dose response of hydroxyapatite

Part 2-2 : Bulk QS-HAp (polynomial function.)

Table.6 Intensity of ESR signal on QS-HAp dose range 0.1 -10 kGy

Dose (kGy)	Intensity (a.u.)
0.1	191816.58
0.2	452538.87
0.4	743780.43
0.8	1469312.06
1.0	1573107.97
2.0	2944184.86
4.0	4601256.67
8.0	7003901.69
10.0	7989371.00

0.1 - 10 kGy → 0.1 – 2 kGy

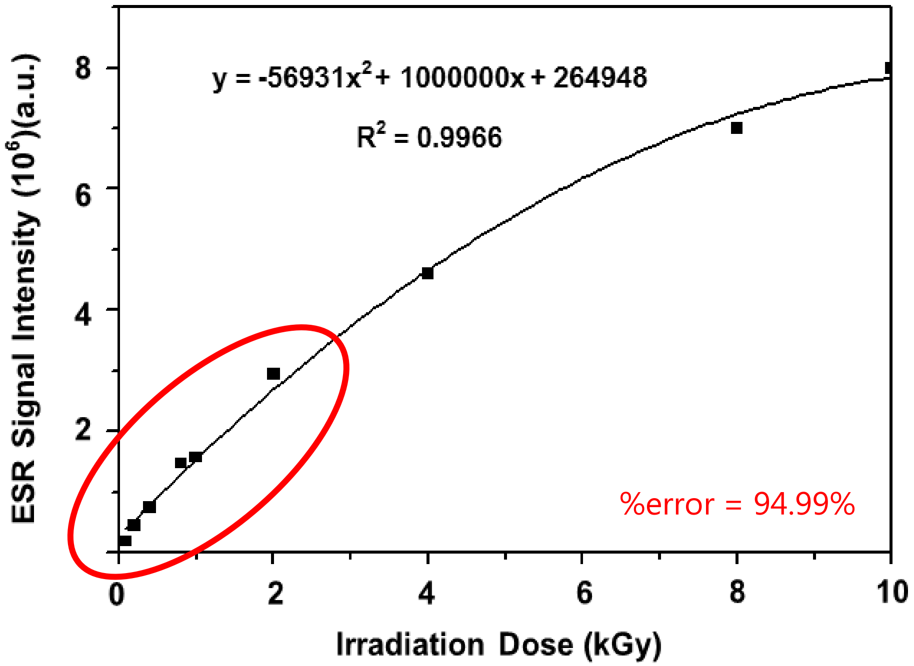


Fig.7 Dose response curve of bulk QS-HAp irradiated with γ radiation at dose 0.1-10 kGy

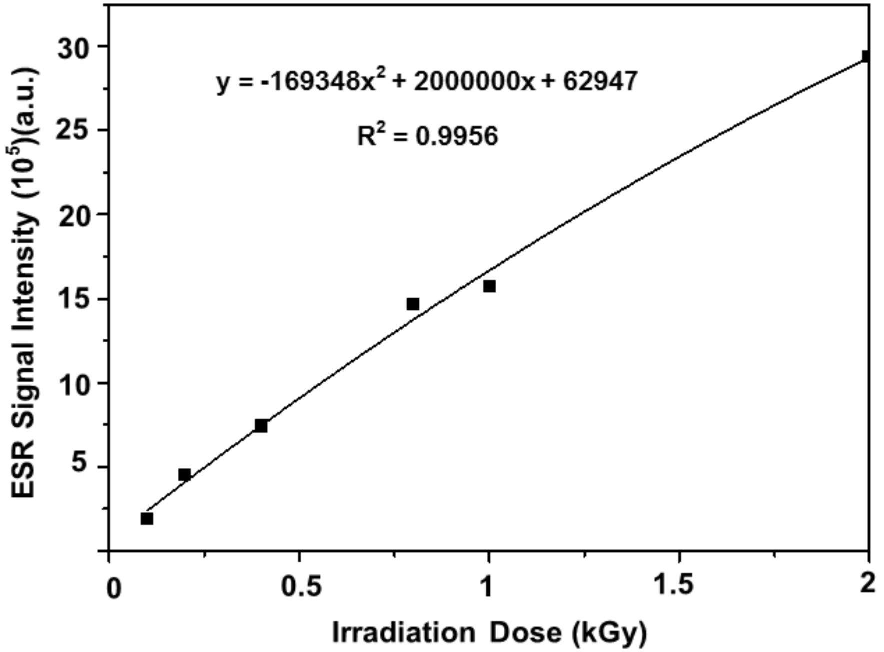


Fig.8 Dose response curve of bulk QS-HAp irradiated with γ radiation at dose 0.1 - 2 kGy

Results & discussion (cont.)

Dose response of hydroxyapatite

Part 2-2 : Bulk QS-HAp (polynomial function.)

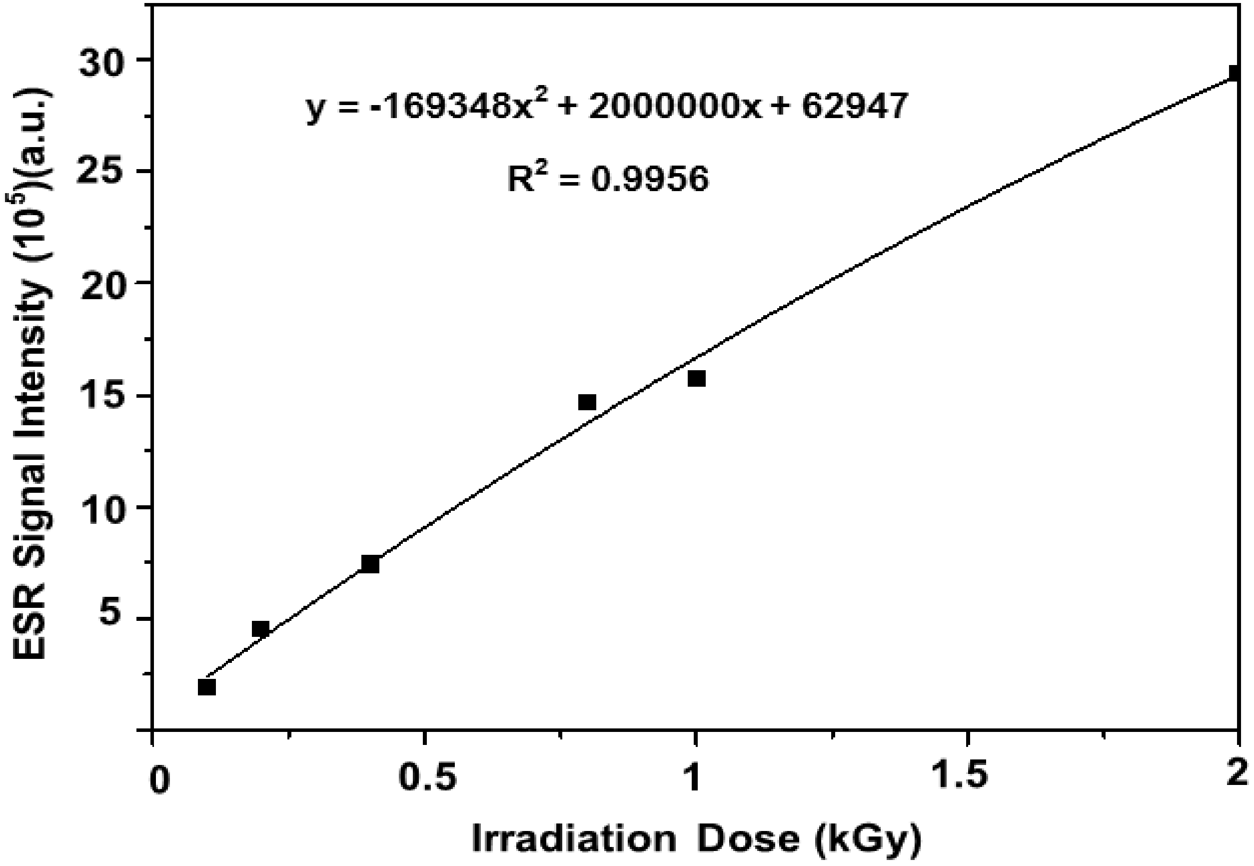


Fig.8 Dose response curve of bulk QS-HAp irradiated with γ radiation at dose 0.1 – 2 kGy

Table 7. Comparison of radiation dose of QS-HAp

Irradiation dose (kGy)	Dose from calibration curve (kGy)	%error
0.2	0.198	0.940
0.4	0.351	12.290
0.8	0.751	6.134
1.0	0.811	18.926
2.0	1.679	16.028

Results & discussion (cont.)

Dose response of hydroxyapatite

Conclusions

Samples	Type	Optimum range (kGy)	Function	Equation	R^2	Maximum error
QS-HAp	powder	0.1 – 10.0	linear	$y = 1000000x + 271003$	0.9933	28.92%
QS-HAp	bulk	0.2 – 2.0	polynomial	$y = -169348x^2 + 2000000x + 62947$	0.9956	18.93%

Results & discussion (cont.)

Fading on hydroxyapatite

Part 3-3 : QS-HAp

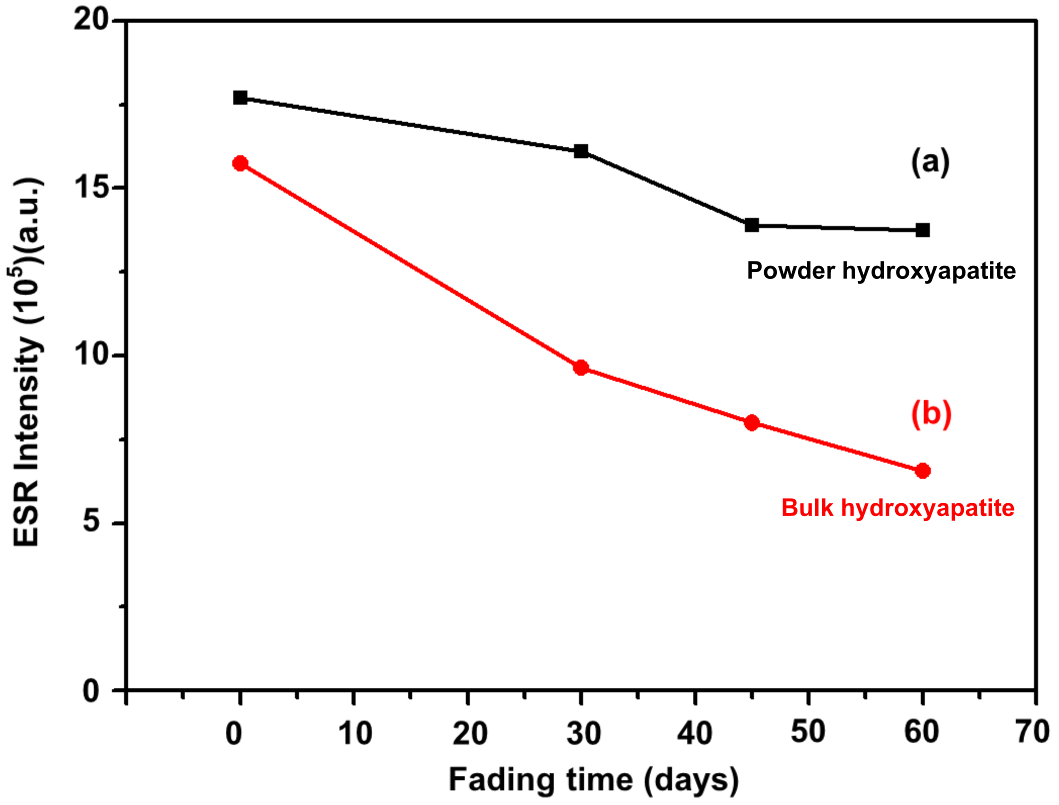


Fig.9 Fading of ESR signal intensity of (a) powder and (b) bulk hydroxyapatite irradiated at 1 kGy

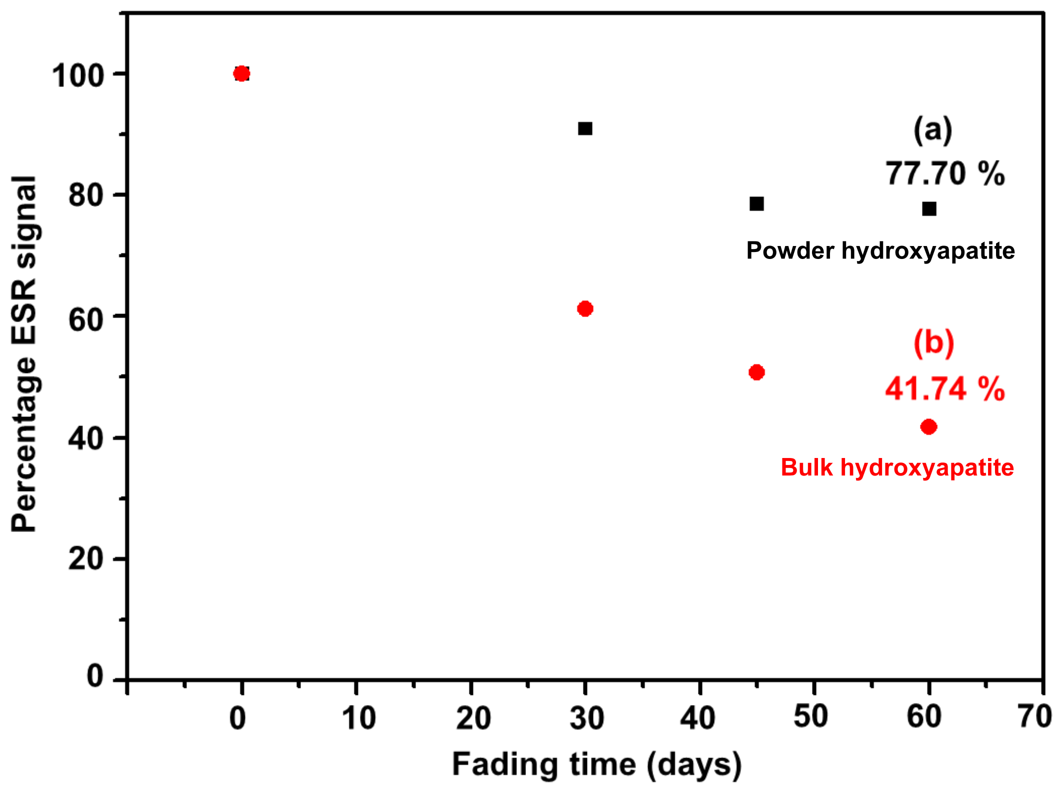


Fig.10 Percentage ESR signal intensity as a function of storage time for (a) powder and (b) bulk hydroxyapatite irradiated at 1 kGy

Conclusions

1. Gamma radiation induced carbonate radicals with a center g-factor of 2.0020 and indicated that hydroxyapatite from quail eggshell has characteristic and properties similar to hydroxyapatite in bone or tooth human.

2. Powder and bulk hydroxyapatite from quail eggshell could be used the best dosimeter in the range of 0.1 – 10.0 kGy and 0.2 – 2.0 kGy, respectively.

3. Hydroxyapatite from quail eggshell can use to be a dosimeter for routine dosimetry.

References

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THANK YOU
for your attention!