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Original Article

Impact of Double Irradiations on the Structural and Micro-structural Features of some Selected Solid Phase -Milk Products

Khaled M. Elsabawy*[1,2]

[1]Materials Science Unit, Chemistry Department, Faculty of Science-Tanta University-31725-Tanta-Egypt
[2]Department of Chemistry, Faculty of Science, Taif University, 888 , Zipcode 21974-Taif, Kingdom Saudi Arabia

*Corresponding author e-mail: khaledelsabawy@yahoo.com

ABSTRACT

Objective: the present studies discuss impact of two different kinds of irradiations (high energy Nd-Laser and Gamma – irradiations which has oxidative nature by additional to its thermal effects) on the micro-structural parameters (grains ,particles sizes) of milk samples.
Methodology: the investigated samples will be examined spectrophotometrically and structurally before and after radiations to confirm its internal structure features via (XRD, microstructure) (SEM, AFM, Raman-Spectra) respectively. Also many of irradiation parameters will be tested such as strength of irradiation dose and irradiation dosage time.
Results: XRD proved that the main crystal structure still as it is, AFM &SEM indicated that huge changements on microstructure features were observed as function of irradiation dose increase.
Conclusion: The results indicated that two applied irradiations sources have no impact on the main crystallographic structure of applied sample only micro-structural features are changed.

Keywords: Nd-Laser; Gamma-ray; Grain Size; X-ray; SEM; AFM.

INTRODUCTION

Irradiation sources[1-15] such as Gamma rays, different kinds of Laser are generally used for the sterilization of gaseous, liquid, solid materials, different kinds of systems . Gamma irradiation is not only applied as clean tool of decontamination, because it has killing effect to bacteria by damaging bacterial DNA, inhibiting bacterial infections[16-30]. The gamma ray action involve photon-induced mechanism incorporated with changes at the cell level cause the death of infected active micro-organisms. The gamma irradiation process is clean and ecofriendly technique due to it does not create active residuals or any impart radioactivity.[22-28].

The hazardous radiolytic active products of water are mainly formulated by indirect action on water molecules yielding free radicals OH., e- aq and H. The action of the hydroxyl radical (OH.) must be responsible for an important part of the indirect effects. Drying or freezing of living organisms can reduce these indirect effects[31-34]. Greez *et al*[31] have investigated the action of radiation on bacteria and viruses and effective use of optimized, high dose (50kGy) gamma irradiation for pathogen inactivation of human bone allographs. They confirmed that sterilizing by gamma irradiation is physical and experimental condition dependent.

Many researchers have investigated the different types of microorganism, mainly bacteria and, less frequently, moulds and yeasts, which found on many medical devices and pharmaceuticals apparatus[35-44].

Many hypotheses have proposed and tested regarding the mechanism of cell damage by radiation. Some scientists postulate the mechanism thought 'radio-toxins' that are the toxic moiety produced in the irradiated cells responsible for lethal effect. Others proposed that radiation was directly damaging the cellular membranes tissues . In addition, radiation effects on enzymes or on energy metabolism were postulated. The effect on the cytoplasmic membrane appears to play an additional role in some circumstances[45] .

Kaplan *et al*.[45] investigated the effects of gamma irradiation of whole chicken carcasses on bacterial loads and fatty acids and contradict with some hypotheses mentioned above .

The aim of the present investigations are aiming to investigate the impact of two different kinds of irradiations on the micro-structural features of solid phase milky products.

EXPERIMENTAL

A. Samples preparation

Two different samples of dry milk were selected to be the target of both Nd-laser and gamma-Irradiation.

B. 1.Laser and Gamma-irradiation sources

The applied laser Nd-pulsed laser has the following parameters: wavelength $\lambda = 1.06$ µm, pulsed rate $\eta = 10^{-3}$ s. The targets were irradiated by two different doses of Nd-laser beam irradiations the 1st 10 W/cm^2 for 5 min., 2nd 20 W/cm^2 for 10 min. The irradiation was carried out in air without any external heating .The energies of pulsed Nd-laser were sufficient to melt homogeneously the surface and near surface layers .SEM was used for monitoring the morphological changements .After laser-irradiation doses all sample were irradiated with gamma-ray 10 MR at distance =20 cm using ^{137}Cs as source for gamma-ray[46-48] .

C. Phase Identification

The X-ray diffraction (XRD) measurements were carried out at room temperature on the fine ground samples using Cu-K$_\alpha$ radiation source,Ni-filter and a computerized STOE diffractometer/ Germany with two theta step scan technique.

Scannig Electron Microscopy (SEM) measurements were carried out at different sectors in the prepared samples by using a computerized SEM camera with elemental analyzer unit (PHILIPS-XL 30 ESEM /USA) .

Atomic force microscopy (AFM): High-resolution Atomic Force microscopy (AFM) is used for testing morphological features and topological map (Veeco-di Innova Model-2009-AFM-USA). The applied mode was tapping non-contacting mode. For accurate mapping of the surface topology AFM-raw data were forwarded to the Origin-Lab version 6-USA program to visualize more accurate three dimension surface of the sample under investigation. This process is new trend to get high resolution 3D-mapped surface for very small area ~ 0.1x0.1 μm^2 [49,50].

D. FT-Infrared Spectroscopy

The infrared spectra of the solid products obtained were recorded from KBr discs using a Shimadzu FT-IR Spectrophotometer in the range from 400 to 4000 cm^{-1}.

RESULTS & DISCUSSION

Two different samples of dry milk were selected to be the target of both Nd-laser and gamma-Irradiation. The two samples symbolized as M1 and M2 respectively. Many of spectral and structural investigations of the samples (M1, M2) under investigations were performed as function of irradiation dose what ever it Laser or Gamma-irradiations.

Fig.1a shows AFM-TM-deflection centers which describes the distribution dots represents pinning centers inside bulk of dry milk sample that be responsible for conduction inside bulk of material .The estimated grain sizes were found in between 1.3-3.2 µm for sample M1 while 2.1-4.1 µm is for M2-sample .Fig.1b display surface topology of M2-sample with magnification factor = 0.2 µm ,it was noticed that there are two different levels of array parallel to each other with average grain size in between 2.1-4.1 µm which is relatively high in contrast with grain size of sample-M1 due to difference in solvent applied in extraction process.

Figs.$2_{a,b}$ describe real and visualized 3D-AFM-Surface topology of M1-sample before laser-irradiation dose. The visualized investigations confirmed the results obtained from AFM regarding averages of particle as well as grain size. From Fig.2_b it was notified that the maximum heights were ranged in between 1.86-1.90 µm (orange-red zones) while minimum heights recorded 1.64-1.67 µm (black-blue zones).

Fig.3a,b displays fingerprint pattern evaluated for dry milk samples M1,M2 respectively. Although the two dry milk sample from two different factory the internal lattice structure is fitted by ratio higher than 60 % percent as clear in Fig.3a,b where red circle refer to fingerprint of internal lattice structure which is mainly lactose beside certain amount of lipids as impurity phases .

From Fig. 4a,b one can notify that the average grain size of sample M1 &M2 before irradiation was found in between 1-4.5µm which is consistent with data evaluated from AFM-investigation mentioned before . But the topological features of sample M1&M2 after 1st and 2nd laser irradiation dose are completely different such the surface's layers and near surface layers reformed as small aggregated zones with different grains shapes as clear in F.4b.

Fig.5 displays IR-spectra recorded for dry milk samples (M1 & M2) after and before laser dose irradiations .It was observed that dry milk samples (M1,M2) still having the function groups even after 2nd irradiation Nd-laser dose as clear in Fig.5. The black circles refer to broad characteristic peak for applied milk sample and no remarkable differences as laser dose increase .These results support the opinion that declare that applied Nd-laser irradiation dose within the save limits in which crystal structure of milk does not changed as proved in our X-ray measurements.

CONCLUSIONS

The conclusive remarks inside this article can be summarized in the following points;

1- Applied irradiation doses have negligible effect on structure phase.
2- Grains and particles sizes enlarged as irradiation dose increase.
3- Micro-structural properties are sensitive to irradiation.

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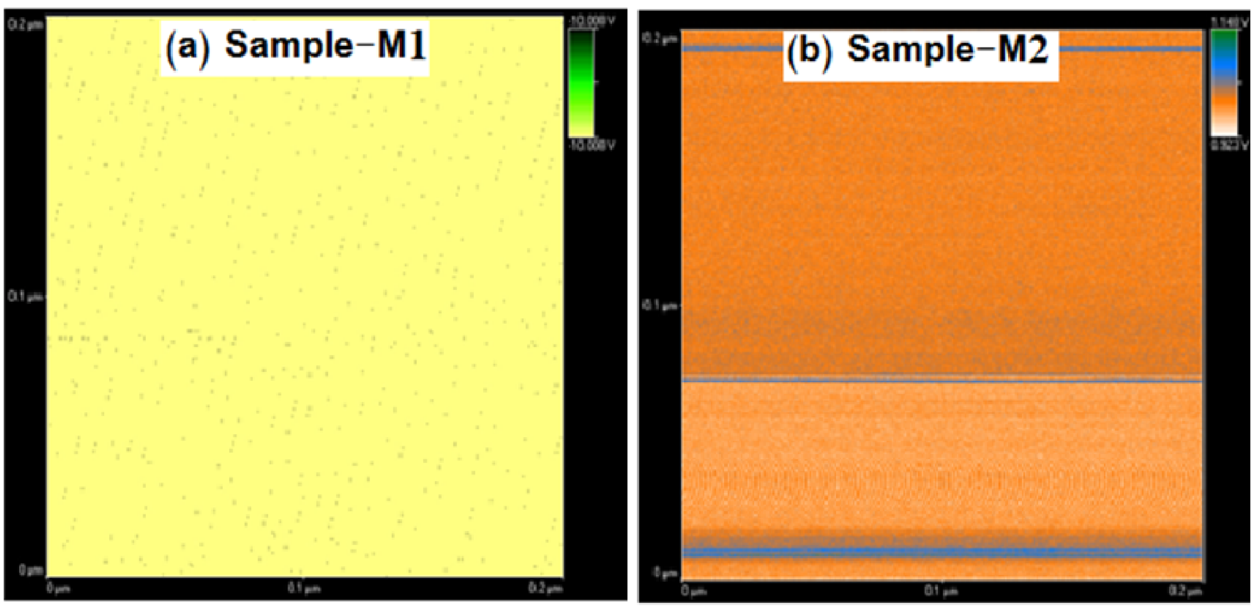

Figure 1a,b. AFM-Investigations of Grain size of applied Milk-powder M1 and M2 samples.

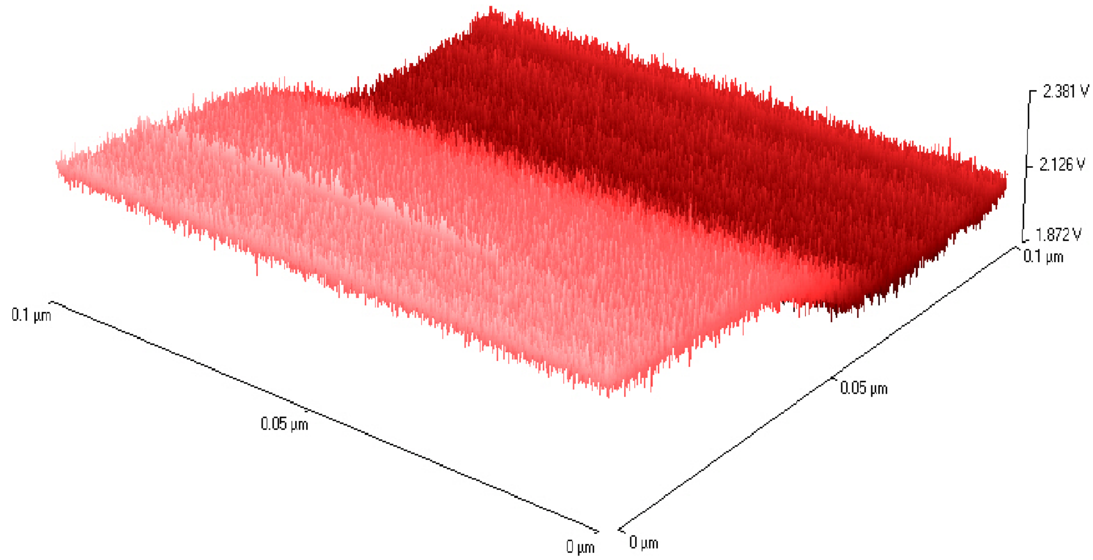

Figure 2a. 3D-AFM-Surface topology of M1-sample before laser-irradiation dose.

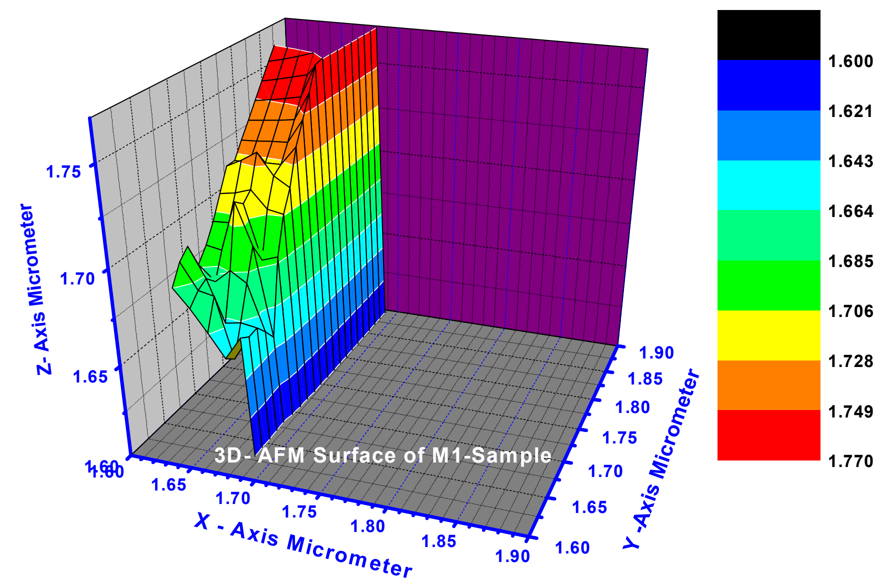

Figure 2b. Visualized 3D-AFM-Surface topology of M1-sample before laser-irradiation dose for area 0.3x0.3 µm^2.

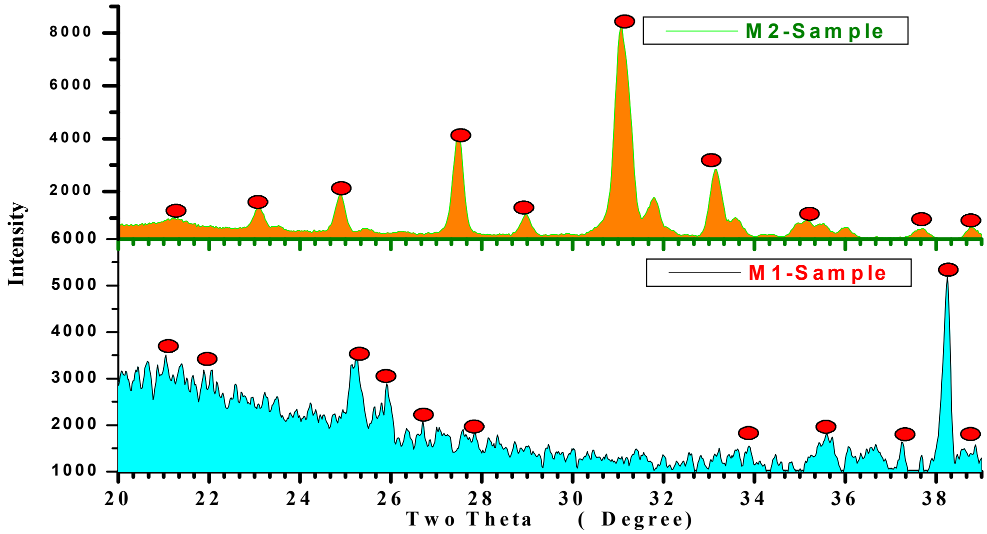

Figure 3a,b. RT-XRD-pattern recorded for samples (M1&M2) respectively.

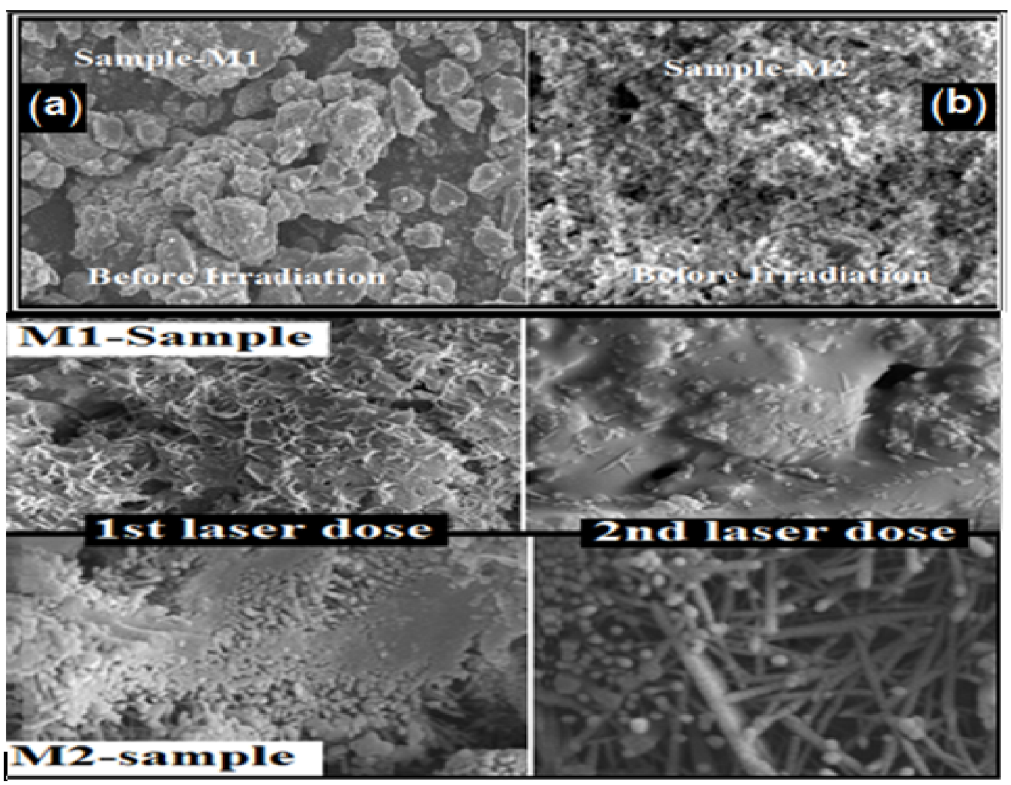

Figure 4a,b. SE-micrographs recorded for M1and M2-samplesBefore and After 1st and 2nd laser irradiation dose.

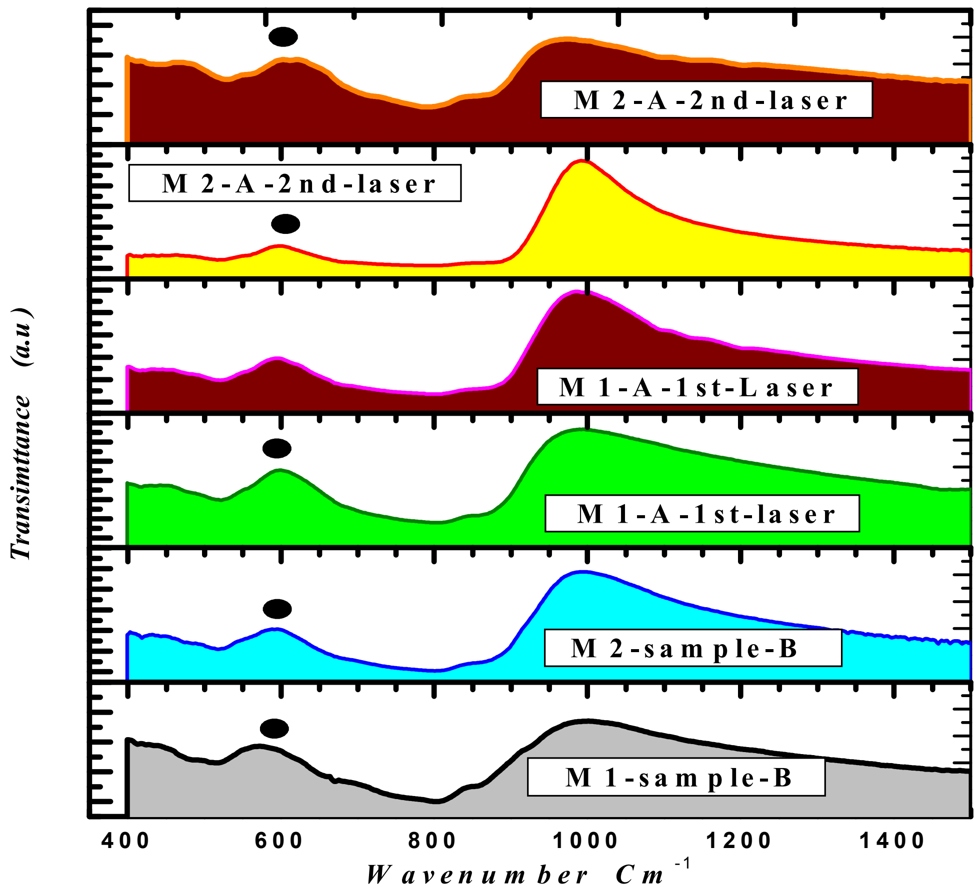

Figure 5. IR-spectra recorded for dry milk samples (M1 & M2) After and Before laser dose irradiations.