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Coupling Between Laser Irradiation and TiO_2 Nanoparticles on Efficient Decontamination of Some Pesticide's Residues from Orange and Tomato Puree

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Abstract

In this paper, we focused on the development of photocatalytic degradation to be a promising method for the treatment of decontaminated fruits and vegetables with pesticides. We investigate the coupling between Laser irradiation with TiO_2 nanoparticles catalyst in order to study the photocatalytic degradation of metalaxyl, chlorpyrifos, and diazinon from artificially contaminated tomato puree and orange puree. Degradation products were identified by gas chromatography-mass spectrometry (GC–MS). The influences of different parameters such as catalyst concentration, irradiation time on the reaction rate were ascertained and optimum conditions for maximum degradation were determined. The degradation percentage of all pesticides was achieved under optimized conditions (1g/L catalyst at the irradiation time of 120 min). The study proved that the coupling between TiO_2 nanoparticles and laser irradiation has a high potential for photocatalytic degradation of diazinon, chlorpyrifos, and metalaxyl from orange puree and tomato puree. And also, proved that the efficient degradation of pesticide residues increased with an increase in laser irradiation time (for 60 min) and catalyst (TiO_2nanoparticles) dosage in all experiments. Maximum reduction >80% was observed in diazinon in all puree treatments. The processing factor (PFs) was generally less than one which indicates that all processes can reduce pesticide residues in all puree treatments. The less efficient removal of pesticides residues from all treatments without Laser irradiation (dark $TiO_2$100mg). We concluded that the optimum conditions for the photodegradation of diazinon, chlorpyrifos, and metalaxyl in all puree treatments were TiO2100mg catalyst concentration and after 60 min of laser irradiation.

Keywords: Photocatalysis; Laser irradiation; pesticides residues; Titanium dioxide nanoparticles; PFs

1. Introduction

Oranges and tomatoes have high economic value, as well as a large number of diseases, insects, and mites that infest them during the growing season, significant quantities of pesticides are often necessary to protect the crops. This may lead to residues on (or/in) the fruit and vegetable at harvest.

Currently, pesticides are widely used in agriculture to ensure good yields and proper harvesting as well as minimal storage losses. Most pesticides are resistant to chemical and/or photochemical degradation under typical environmental conditions [1]. The presence of pesticides residues in water and food-chains may have a harmful effect on human health and on the equilibrium of ecosystems [2].

Much research effort has been invested into the reduction of pesticides and its by-products with different approaches such as household processing,[3] nano-filtration Particle ozonation [4, 5], Photolytic degradation of different organophosphorus compounds has been intensively studied [6]. To improve photodegradation aqueous suspensions of semiconductors in combination with UV irradiation have been used. Among the applied semiconductors titanium dioxide (TiO_2) has proven to be the most efficient one due to its capability to form electron-hole pairs under illumination with UV light.

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The combinations of UV–H_2O_2, UV–TiO_2 and UV–H_2O_2–TiO_2 have also been used for photo-degradation of some organophosphorus compounds, including diazinon [7].

Wang *et al* [8] stated that photocatalysis represents an attractive means to not only remediate polluted waters, but also harness solar energy. But the employment of photocatalysts remains a practical challenge in terms of high cost, low efficiency, secondary pollution, and unexploited water matrices influence.

Titanium dioxide (TiO_2) considered as a catalyst of choice for such surface reactions as it has good chemical stability, low cost, and high UV photoactivity, Titanium oxide (TiO_2) is regarded as the most suitable photocatalyst for the degradation of organic pollutants.

The nano-TiO_2 photo semiconductor continues to attract attention of agricultural researchers because of its favorable physical/chemical properties, low cost, availability, and high stability. Thus, nano-TiO_2 photo semiconductors have many application possibilities in agriculture including degradation of pesticides, plant protection, and residue detection [9].

Moreover, the use of technologies like nanoparticles should be promoted as being efficient, cheap and environmentally friendly [4].

Budarz *et al* [10] study chlorpyrifos degradation experiments employing TiO_2 as the radical generator often employ high concentrations of the catalyst (0.1–12 g. L^{-1}) in an effort to maximize radical production and minimize treatment time, with chlorpyrifos loss often occurring within. Furthermore, little absorption has been seen for similar pesticides when employing metal oxide nanoparticles (NPS).

Laser-induced photocatalysis is superior as compared with the conventional sources such as broad UV spectral lamps. Photocatalysis was capable of removing phenol toxicity, generating effluents that are not toxic like CO_2 and water [11].

Laser flash photolysis (LFP) is a technique used to study transient species generated by an intense, several nanosecond-long light pulses from a pulsed laser source, monitoring the decay and spectra of these species by absorption spectroscopy. A particularly convenient LFP method for studying the reactivity of hydroxyl radical HO• is to generate $HO^{\bullet}$ by direct photolysis of 2-mercaptopurine-N-oxide in acetonitrile24,25 and use trans-stilbene to capture $HO^{\bullet}$ [12].

Processing factors (PFs) are the ratio of residue concentrations after processing to those in the raw commodity. PFs values greater than 1 indicate an increase in pesticide residue concentrations during processing; PFs values less than 1 indicate decreases. PFs depend on both the crop and the physicochemical properties of pesticides. Peeling and storage were found to be two important processing procedures that may remarkably reduce non-systemic pesticide residues in some fruits and vegetables [13].

However, to the best of our knowledge, there are limited studies pertaining to effect of laser irradiation on pesticide degradation, especially in food. This present work, the photocatalytic degradation of the pesticides (chlorpyrifos, diazinon, and metalaxyl) in tomatoes puree and oranges puree, using TiO_2 nanoparticles were investigated. Degradation products were identified by gas chromatography-mass spectrometry (GC–MS).

2. Experimental

2.1. The tested pesticides

Ridomil 72% W.P contains 8% of metalaxyl active ingredient, and commercial helban 48% EC contains 48% of the Chlorpyrifos active ingredient, basudin 60% EC contains60% Diazinon was obtained from the local market.

2.2. *Organic fruit samples*

Organic tomatoes purchased from a local food market (ISIS), Egypt. Organic oranges purchased from BIO COMPANY®, GmbH, Rhein Strasse, Berlin, Germany supplier with certification label.

2.3. Chemicals and reagents

Titanium (IV) oxide (TiO_2) nano powder, 21nm primary particle size (TEM), ≥99.5% trace metals basis, Sigma-Aldrich (St. Louis, MO, U.S.A.). Acetonitrile purchased from (Merck® KGaA, Darmstadt, Germany)., QuEChERS kit: consists of Extraction packets, and Dispersive SPE kit were purchased from (Agilent Technologies, California, USA). Ultrapure water (18.2 MΩ.cm, Milli–Q Plus system, Millipore Bedford, MA, USA) was used throughout all the work., The pesticides Certified Reference Materials (CRM) Metalaxyl 1000µg/ mL and Diazinon 1000µg/ mL dissolved in acetone were purchased from (SPEXCertiPrep®, New Jersey, USA). Chlorpyrifos 1000µg/ mL in methanol, from (Restek®, Pennsylvania, USA).

2.4. Instrument and apparatus

Laser source 50mW, Nd: YAG second harmonic, 532 nm, China), Agilent 7890B Gas Chromatograph coupled to Agilent 5977A Mass Spectrometer (Agilent Technologies Inc., Wilmington, USA), A Laboratory Blender (Waring, Stamford, USA), centrifuge (BOECO, Hamburg, Germany), MMS 3000 magnetic stirrer (BOECO, Hamburg, Germany) with speed 0-3000 1/min).

2.5. Puree preparation and artificial contamination

organic fruits were manually washed in distilled water and dried with filter paper then tomatoes fruit and orange pulp were cut coarsely (3 cm x 3 cm) with a knife and homogenized in a blender to obtain tomato puree and orange puree respectively, the total solid of each was adjusted to 12 % by means of handheld digital refractometer, subsequently, each solution was contaminated by adding 0.5 g ridomil 72%, 2 ml of helban 48% and 2 ml of ectodat 60 EC per litre, magnetically stirred in the dark for 30 min to ensure complete homogenization, an aliquot of these purees were analysed in order to get the concentration of the initial pesticide (Control sample).

2.6. The photocatalysis experiments were conducted as follows

Experiments have been carried out in a batch reactor made up of borosilicate glass, Duran®, Germany (diameter 7.0 cm and 9 cm in height), using Nd: YAG laser source (50mW, 532 nm). In each experiment, a certain dosage of TiO_2 photocatalyst (0–100mg/100ml) was added to 200 ml puree, the experiment performed at room temperature (25^o C) which monitored by the digital data logger, (174H Testo Ltd. Alton, Hampshire, United Kingdom), all samples were exposed to air throughout the experiment [14], The solution in the photoreactor was constantly stirred by the magnetic stirrer. The photocatalyst suspension was equilibrated in the dark for 30min. After equilibration, the laser source was switched on and an aliquot of the samples has been isolated in time intervals ranging from zero min to 2hrs [15, 16,17]. The aqueous sample was centrifuged at 4000 rpm for10 min to eliminate photocatalyst and then used for residues quantitation. Test controls were incubated in the dark to ensure that the degradation of pesticides was only due to laser photocatalysis, all treatments were run in triplicate.

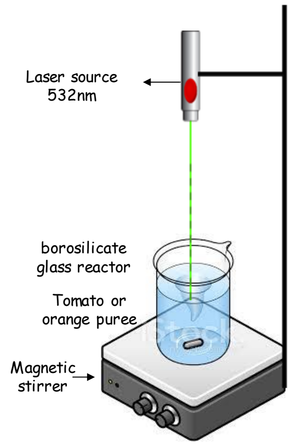

Figure 1 Schematic diagram of Photoreactor set up.

2.7. GC MS analysis for estimation of pesticides degradation

During the experiments, concentrations of pesticides were quantified by an Agilent Gas chromatograph (GC) 5977A, equipped with a mass detector and a capillary column Zebron ZB-5M S Phenomenex, Torrance, CA, USA. The pesticides present in the samples after laser after laser irradiation were extracted using QuEChERS, [18] and the extracted phase was introduced in the GC MS for the analysis. More experimental details on the analytical methods can be found at our previous research article [3].

2.8. Processing factors (PFs):

The PFs values of <1 indicates a reduction in residues in a processed commodity, whereas the values of >1 indicates concentration effects from the processing procedures PFs was calculated according to the following equation:

$$PFs = \frac{\text{Residues in processed product (mg/ Kg)}}{Residues\ in\ raw\ agricultural\ commodity\ \ (mg/\ Kg)}$$

3. Results and discussion

Removal of laser irradiation, and catalyst dosageTiO_2 on three pesticides, from tomato puree, was studied.

3.1. Tomato Puree

3.1.1. Diazinon

The change in absorption intensity as a function of laser irradiation time of the diazinon in Tomato puree samples in the absence and presence of TiO_2 has studied laser irradiation with photocatalyst using Laser irradiation and TiO_2 nanoparticles with (0.0 mg,50 mg ,100 mg100ml) and without Laser irradiation (dark $TiO_2$100mg) depicted in Figure2.

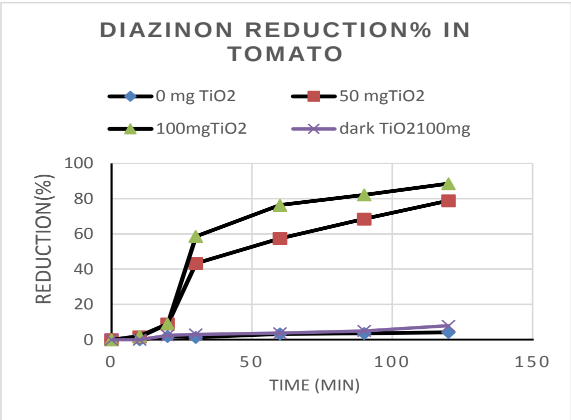

Fig 2 Effect of photocatalyst TiO_2) concentration on the photodegradation of Diazinon reduction percentage% in tomato puree

These results indicate that performed about 4.2%, 78.8%, 88.5%. 7.9% reduction percentage% of (0.0 mg, 50 mg, 100 mg, TiO2, and dark condition) respectively of the diazinon in Tomato puree samples. Removal of diazinon in Tomato puree samples was observed after a period of 2 hours diazinon in Tomato puree samples were achieved within laser irradiation time compare with dark about 7.9 % reduction percentage% of the diazinon in Tomato puree samples.

The percentage degradation estimated using the following relation:

Reduction percentage (%) = $[C0 - Ct/C0] * 100$

Nguyen Minh Phuong et al [19] obtained results indicated that the Fe-TiO_2/Bent-Fe exhibited high photocatalytic degradation activity for removal of diazinon even under visible light.

The diazinon removal experiments were also conducted using different photocatalyst dosages, under different pH and light sources to figure the optimal conditions for removal processes. The obtained results indicated that optimal photocatalyst dosage and pH were 0.5 g/L and 4.5, respectively. Finally, the natural light generated from solar could be suitably used for diazinon removal by the synthesized Fe-TiO_2/Bent-Fe

3.1.2. *Chlorpyrifos*

As a function of laser irradiation time of the chlorpyrifos in Tomato puree samples in the presence of TiO2 studied. Photocatalyst using Laser irradiation and TiO_2 nanoparticles with (0.0 mg, 50 mg, 100 mg100ml) and without Laser irradiation (dark $TiO_2$100mg is depicted in Figure3.As soon as the catalyst added, chlorpyrifos adsorbed on the surface, thus lead to increase photolysis of the reduction to 84.26% reduction after 2 h of irradiations in chlorpyrifos in Tomato puree. Generally. the use of catalyst with dark conditions till less degradation %for chlorpyrifos in Tomato puree sample. The degradation of the chlorpyrifos in the tomato puree sample using TiO_2 (0.0, 50.100mg, dark condition without laser irradiation) showed (7.41, 70.83, 84.26, 10.0 %) of chlorpyrifos in respectively in tomato puree sample depicted in Figure3.

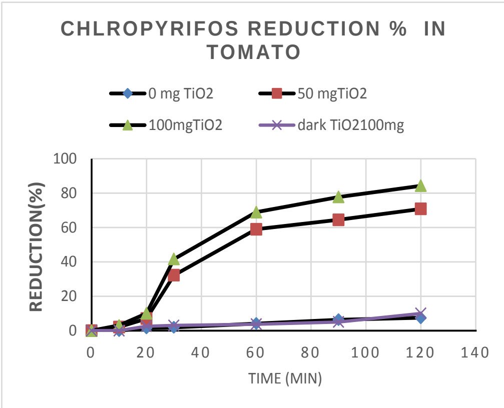

Fig3: Effect of photocatalyst(TiO_2)concentration on the photodegradation of Chlropyrifos reduction percentage in tomato puree

3.1.3. Metalaxyl

We further investigated the effect of TiO_2 concentration and laser irradiation on the metalaxyl reduction percentage in the Tomato puree sample. Data presented in Figure 4

In the presence of TiO_2, there is evidence of a very small decrease even after 10 min. By contrast, both the 50 mg TiO_2 and 100mg TiO_2 act as effective photocatalysts for the metalaxyl reduction percentage in tomato puree Samples

Moreover, the metalaxyl reduction percentage by using Laser irradiation and TiO_2 nanoparticles with (0.0 mg, 50 mg, 100 mg/100ml) and without LP (dark $TiO_2$100mg) showed 7.23, 76.22, 79.38%) respectively of metalaxyl in tomato puree sample in Figure 4

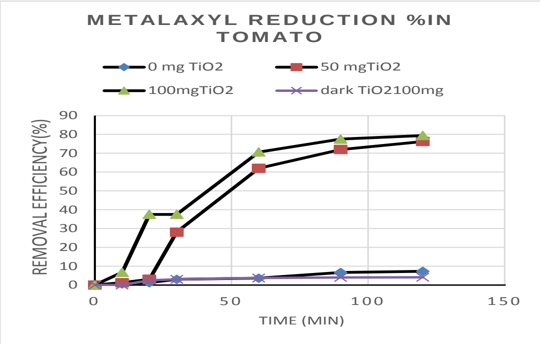

Fig4: Effect of photocatalyst (TiO_2) concentration on the photodegradation of Metalaxyl reduction percentage in tomato

Also performed similar measurements to investigate the photocatalytic behavior when using laser irradiation Figure 4 shows the different photocatalyst (TiO_2 100mg) and dark without laser irradiation ($TiO_2$100mg). Clearly, Photocatalysis of laser irradiation (TiO_2 100mg) is more effective in promoting the photocatalysis. The reduction percentage was about 79.38% of the initial concentration of metalaxyl reduction percentage in tomato puree sample whereas, using dark 4.1% of the concentration of metalaxyl reduction percentage in tomato puree sample.

Therefore, the photocatalysis increases using the TiO_2 and laser irradiation.

Results revealed that using laser irradiation and Catalyst dose both decreased the residues of all the pesticides in tomato. Removal increased with an increase in laser irradiation time. The decreasing trend of pesticide concentration by various decontamination methods and GC chromatograms representing the same for respective pesticides in tomato puree

3.2. Orange puree

3.2.1. *Diazinon*

Initial deposit of Diazinon in the orange puree as calculated by the analysis of laser irradiation fortified samples was found to be varying between 29.32-16.16%

Figure 5. Shows the percent degradation of Diazinon in orange puree

Degradation of Diazinon residues in orange puree increased with an increase in time of laser irradiation. Blank experiments carried out for the Diazinon in orange puree without theTiO_2 catalyst. No significant degradation (almost 3.64%) observed in Figure5.

The experiment with laser irradiation in presence of TiO_2 nanoparticles with (0.0 mg, 50 mg, 100 mg100ml) and without Laser irradiation (dark $TiO_2$100mg). TiO_2 nanoparticles with (50 mg, 100 mg) have been performed initially and about 70.68, 83.84% for the Diazinon in orange puree. Removal of Diazinon in orange was observed after a period of 2 hours.

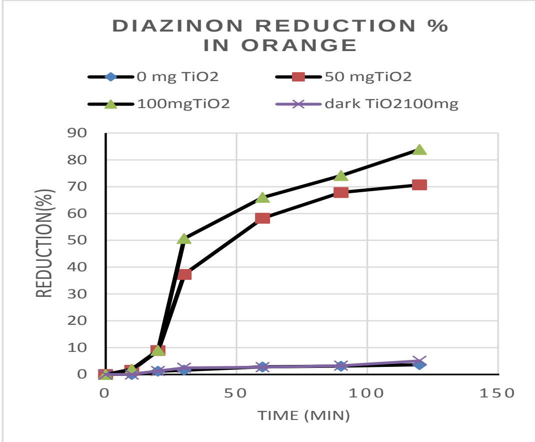

Fig 5 Effect of photocatalyst (TiO_2) concentration on the photodegradation of Diazinon reduction percentage% in Orange puree

This is due to the physical adsorption of the Diazinon in orange and on the catalyst surface.

Also, the change in absorption intensity as a function of laser irradiation time of the Diazinon in an orange puree in the presence of TiO_2 nanoparticles was studied laser irradiation with (photocatalyst TiO_2 nanoparticles 100mg) and without (dark $TiO_2$100mg) depicted in Figure4. These results indicate that almost 83.84% reduction percentage of the Diazinon in puree were achieved within laser irradiation time compare with dark about 5.1% reduction percentage of the Diazinon in orange puree.

The results demonstrate that 58.24%to, 65.99% removal of Diazinon in orange were achieved during 60-minute laser irradiation using TiO_2 addition time, the percentage of diazinon reduction increases. This increase in diazinon reduction with time could be due to an increase in radicals.

Doong and Chang, [7] indicated that a combination of H_2O_2 and TiO_2 under near UV illumination shows much promise in the photodegradation of some organophosphorus compounds, including diazinon and their eventual detoxification in water.

3.2.2. Chlorpyrifos

Figure 6. Showed more reduction percentage observed (7.10, 68.01, 82.04%) respectively of chlorpyrifos in orange puree in presence of laser irradiation and TiO_2 nanoparticles with (0.0 mg, 50 mg, 100 mg/100ml) and without Laser irradiation (dark $TiO_2$100mg).

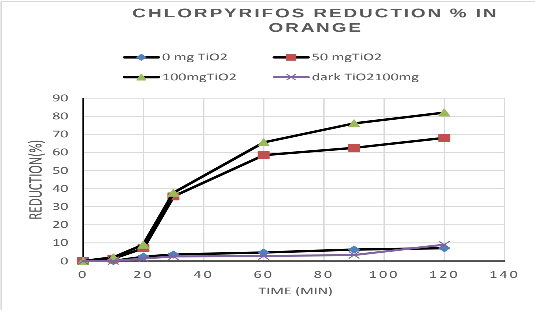

Fig6: Effect of photocatalyst(TiO_2)concentration on the photodegradation of Chlorpyrfos reduction percentage in Orange puree

As a function of laser irradiation time of the chlorpyrifos in an orange puree in the presence of TiO_2 studied. photocatalyst (TiO_2 100mg) and dark without laser irradiation (TiO_2 100mg) are depicted in Figure4. As soon as the catalyst added, chlorpyrifos adsorbed on the surface, thus lead to increase photolysis of the reduction to 82.04% reduction after 2 h of irradiations in chlorpyrifos in orange puree. Generally, the use of catalyst with dark conditions until less degradation %for chlorpyrifos in the orange puree as clear from figure 6.

Laser-induced photocatalysis is superior as compared with the conventional sources such as broad UV spectral lamps. Photocatalysis was capable of removing phenol toxicity, generating effluents that are not toxic like CO2 and water [11].

Verma, and Dixit, [23] reported that the photocatalytic oxidation of chlorpyrifos insecticide had been studied using TiO_2 as a photocatalyst and H_2O_2 as an oxidant. Studies reveal that photocatalytic oxidation of the insecticide in a shallow pond reactor can efficiently be done. The optimum conditions for the photodegradation of insecticides are 4 $g.L^{-1}$ catalyst concentration, 3.0 g. L^{-1} H_2O_2, and 6.5 pH.
Budarz et al. [10] investigate the photo reactivity of titanium dioxide nanoparticles, the capability to degrade the pesticide chlorpyrifos, and the effect of an impact on bacteria during the photodegradation process. Loss of chlorpyrifos in solution resulted solely from photocatalytic oxidation, with 80% degradation observed after 24 h in our reactor, either in the presence or absence of bacteria

3.2.3. Metalaxyl

Further investigation has been done to study the effect of TiO_2 concentration and laser irradiation on the metalaxy reduction percentage in orange puree. Data presented in Figure 7

Reduction percentage of metalaxyl using Laser irradiation in presence of TiO_2 nanoparticles with (0.0 mg, 50 mg, 100 mg/100ml) and without Laser irradiation (dark $TiO_2$100mg). Showed (8.70, 68.38, 79.38%) respectively in orange puree.

The photocatalytic behavior when using laser irradiation Figure 7 shows the different photocatalyst (TiO_2 100mg) and dark without laser irradiation (TiO_2 100mg).

Clearly, Photocatalysis of laser irradiation (TiO_2 100mg) is more effective in promoting the photocatalysis. The reduction percentage was about the 79.38% of the initial concentration of metalaxyl reduction percentage in orange puree, whereas, using

Table1: Processing Factors (PFs) value for all photocatalyst treatments in tomato puree

Pesticide	**Catalyst dose mg/L**	**Processing Factors (PFs)**				
		Irradiation time (min)				
		20.0	**30**	**60.0**	**90.0**	**120.0**
Diazinon	**50**	0.92	0.58	0.44	0.33	0.22
	100	0.92	0.42	0.25	0.19	0.12
	100(dark)	0.99	1.00	0.99	0.96	0.98
Chlorpyrifos	**50**	0.94	0.69	0.43	0.37	0.32
	100	0.91	0.59	0.32	0.28	0.17
	100(dark)	0.99	0.99	1.00	1.01	1.01
Metalaxyl	**50**	0.98	0.74	0.39	0.30	0.26
	100	0.63	0.64	0.30	0.24	0.23
	100(dark)	0.99	1.00	1.00	1.03	1.03

$$\textbf{PF}= \frac{\textbf{Residues in processed product (mg/ Kg)}}{\textit{Residues in raw agricultural commodity (mg/ Kg)}}$$ **(Timme and Walz 2004)**

dark without laser irradiation (TiO_2 100mg) 5% of metalaxyl reduction percentage in orange puree was still present

Therefore, the Photocatalysis increases using the TiO_2 and laser irradiation.

Under sunlight, methomyl and metalaxyl have shown efficient degrading with photocatalysis using TiO_2 supported over activated carbon (10-AC), as a result, the quantity adsorbed of both pesticides on the 10-AC surface increased by more than ten times compared with TiO_2. 10- AC catalyst degradation efficiency was a little bit less than TiO_2 ones [2].

3.3. Effect of processing

Processing factors (PFs) related to TiO2 concentration and laser irradiation process were determined. Processing factors were generally below 1 for all of the studied pesticides, and only the use of catalysts with dark conditions in all puree treatments exhibit PFs above 1. The behavior of PFs is shown in Table 1, 2. In the dark or photocatalyst without light, no change is observed.

Table 1 shows the PFs values of the effect of TiO2 concentration 100mg and laser irradiation on the chlorpyrifos, metalaxyl and diazinon in Tomato puree after (30-60-90-120min). PFs values of diazinon ranged 0.42, 0.23, 0.19and 0.12 respectively. While, the PFs values of Chlorpyriphos represented the values (0.5946, 0.3239, 0.2375and0.1700) respectively. On other hand the PFs values of metalaxyl represented the values (0.6443, 0.3044, 0.2410 and 0.2331) respectively. A gradual reduction was noted when the time was increased. The same trend was observed in PFs values of TiO2 concentration 100mg and laser irradiation on the 3 pesticide residues in orange puree treatments after (30-60-90-120min) in table 2.

The effectiveness of this process resulted in significantly reduced (over 50 %) the concentrations of three pesticides residues in orange puree after 60min.

Therefore, the status of pesticide residue affects the removal of pesticide residue from vegetable. This may be mainly attributed to the difference in the physicochemical properties of the pesticides these data are consistent with other studies conducted on tomato [3], where increasing the time of the process yielded a lower PF.

4. Conclusions

The results, focused on the development of Photocatalyst degradation is a promising method for reducing pesticide contamination treatment of fruits and vegetables.

The photocatalytic degradation of the pesticides (chlorpyrifos, diazinon, and metalaxyl) in tomatoes puree and oranges puree, using Laser irradiation and TiO2 nanoparticles with concentration (0.0 mg, 50 mg, and 100 mg/100ml) and without Laser irradiation (dark with$TiO_2$100mg) were investigated. Degradation products were identified by gas chromatography-mass spectrometry (GC–MS). Degradation of pesticide residues increased with an increase in laser irradiation time and Catalyst (TiO_2 nanoparticles) dose. Catalyst dosage for 60 min. was effective in removing the residues of Diazinon, chlorpyrifos, and metalaxyl in all experiments. Maximum reduction of more than 88.5% was observed in case of diazinon in tomatoes puree.

Table2: Processing Factors (PFs) value for all photocatalyst treatments in orange puree

Pesticide	Catalyst dose mg/L	Processing Factors (PFs) Irradiation time (min)				
		20.0	**30**	**60.0**	**90.0**	**120.0**
Diazinon	**50**	0.92	0.64	0.43	0.33	0.30
	100	0.92	0.50	0.35	0.27	0.17
	100(d)*	1.00	0.99	1.00	1.00	0.98
Chlorpyrifos	**50**	0.95	0.67	0.44	0.40	0.34
	100	0.93	0.65	0.36	0.26	0.19
	100(d)*	1.01	1.0	1.02	1.03	1.01
Metalaxyl	**50**	0.95	0.88	0.81	0.58	0.35
	100	0.88	0.64	0.31	0.27	0.23
	100(d)*	0.98	0.98	1.00	1.02	1.04

PF= $\frac{\text{Residues in processed product (mg/ Kg)}}{Residues\ in\ raw\ agricultural\ commodity\ \ (mg/\ Kg)}$ (Timme and Walz 2004), * d: dark

Generally, the use of catalysts with dark conditions till less degradation % in all purees samples. Clearly, Photocatalysis of laser irradiation (TiO_2 100mg) is more effective in promoting the photocatalysis

We concluded that the reaction follows apparently the degradation efficiencies increased in the order of diazinon > chlorpyrifos> metalaxyl. The PF values for all treatments were lower than one. The less efficient removal of diazinon, chlorpyrifos, and metalaxyl residues from all treatments without Laser irradiation (dark $TiO_2$100mg). The optimum conditions for the photodegradation of diazinon, chlorpyrifos, and metalaxyl are $TiO_2$100mg catalyst concentration and after 2 h of laser irradiation

5. Conflicts of interest

"There are no conflicts to declare".

6. Acknowledgments

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الجمع بين التشعيع بالليزر وجزيئات ثاني أوكسيد التيتانيوم النانوية لخفض التلوث لبعض بقايا المبيدات في كل من بيورية البرتقال والطماطم

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يعتبر تحلل المحفز الضوئي طريقة واعدة لخفض التلوث بالمبيدات للفواكه والخضروات. الدراسة تهدف تأثيرالجمع بين تشعيع الليزر مع جزيئات TiO_2 النانويةلخفض مبيدات (الميتالاكسيل والكلوربيريفوس والديازينون) في كل من بوريه الطماطم وهريس البرتقال الملوثة صناعياً. تم استخدام الكروماتوغرافيا الغازية لقياس الطيف الكتلي (GC-MS) لإظهار نواتج التحلل الفعال. تم دراسةتأثيرات تركيز المحفز ووقت التشعيع على معدل التفاعل وتم تحديد الظروف المثلى لخفض التلوث. اشارت النتائج ان الظروف المثلى إزالة للتلوث بالمبيدات هى (1 جم / لتر محفز - وقت التشعيع 120 دقيقة). أثبتت الدراسة أن جزيئات TiO2 النانوية والإشعاع بالليزر لهما قدرة عالية على التحلل التحفيزي الضوئي للديازينون والكلوربيريفوس والمالاكسيل من هريس البرتقال وهريس الطماطم..زاد خفض بقايا المبيدات مع زيادة وقت تشعيع الليزر لمدة 60 دقيقة وتركيز المحفز (جزيئات TiO2 النانوية). معامالات البيورية تركيز المحفز لمدة 60 دقيقة. كان فعالاً في إزالة بقايا الديازينون والكلوربيريفوس والميتالاكسيل في جميع التجارب. لوحظ الحد الأقصى من التخفيض> 80٪ في الديازينون في جميع معاملات البيورية. كما لوحظ ان استخدام المواد الحفازة في ظروف مظلمة خفضت نسبة التحلل في جميع معامالات البيورية.
وكان تأثيرالمعاملات (PFs) بشكل عام أقل من واحد مما يشير إلى أن جميع المعاملات يمكن أن تخفض التلوث من بقايا المبيدات. كما اشارت النتائج ان استخدام المواد المحفزة ($TiO_2$100mg مظلم) مع عدم التعرض لاشاع الليزر في وسط مظلم لجميع معاملات البيورية كانت أقل كفاءة لإزالة لبقايا المبيدات من جميع المعالجات
لذا أن الظروف المثلى للتحلل الضوئي للديازينون والكلوربيريفوس والميتالاكسيل في جميع معامالات البيورية كانت تركيز محفز $TiO_2$100mg وبعد 60دقيقةمن التشعيع بالليزر.