Original Article

Adsorption behavior of some metal ions on nanoparticles used in pharmaceutical matrices: Application to laboratory made drug formulation

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ABSTRACT

The adsorption behavior of some metal ions (Pb, Mn, Mg, Zn and Ca) was studied on silicon dioxide nanoparticles, SiO_2 NP, alone and its mixture with microcrystalline cellulose, MCC, powder (1:1) as drug carriers in pharmaceutical preparations. The effect of different conditions as temperature and pH on adsorption was investigated. It was found that upon increasing the temperature, the ability of the adsorbent material increases. The pH of the metal solution has the same effect as temperature till pH 8. However, above pH 8 the adsorbent material began to lose its adsorption efficiency. Although, the use of SiO_2 NP mixture with MCC powder can improve the excipient functionality, it is important to take into consideration their metal adsorption behavior. The study was applied on laboratory made drug formulation contains different drug carriers. The study points at the importance of adjusting the permissible level of metals in different active and inactive ingredients used in pharmaceutical preparations containing nanoparticles as drug carriers. The type of nanoparticles used and the pH of these preparations are important factors affecting the metal adsorption behavior. At the maximum temperature of adsorption, the calculated metal adsorption capacity of a mixture of MCC and SiO_2 NP (1:1) compared to SiO_2 NP alone was found to be 0.2043 and 0.1169 for Pb, 0.1948 and 0.1041 for Zn, 0.2114 and 0.1207 for Mg, 0.2220 and 0.1222 for Ca and 0.2068 and 0.1054 for Mn, respectively. Flame atomic spectrometry was used for determining metal remained concentration after adsorption.
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1. Introduction

Nanoparticles (NPs) have received interest for their potential as drug delivery systems. Yet, most of them have not been sufficiently tested for their potential toxicity [1]. Silica-based nanoparticles are promising drug delivery system because of the several attractive features they possess [1,2]. They are chemically inert with a good biocompatibility and have high surface area and pore volume [1,2]. They enhance the dissolution rate of drugs by adsorption of drug molecules on the surface and pores of the silica carrier using Van der Waals forces and hydrogen bonds. When in contact with water, these bonds can be easily broken to release the drug molecules [3–6]. They also provide a targeted drug delivery system which decrease the non-target tissue and cells toxicity and give the best therapeutic effect. Moreover, NPs decrease the doses of the drug necessary for the therapy, consequently decreases its toxicity [7,8].

However, concerning the safety of silica nanoparticles (SiO_2 NPs), it is reported that SiO_2 NPs can lead to dose-dependent cytotoxicity, lung inflammation and nephrotoxicity [9–12]. Another proposed mechanism of NPs enhancement of metal toxicity which is being investigated through the present study is their adsorption of metals [13] present as traces in the pharmaceutical products. These traces in pharmaceutical products can be found as elemental impurities in the active ingredient, excipients, water used in the preparation and primary packaging material [14]. SiO_2 NPs are able to adsorb metals and concentrate them which may lead to increase the risk of metal toxicity by increasing the metal level in the pharmaceutical preparation doses given to patients.

It is reported that adsorption of metal pollutants from water is highly dependent on pH and temperature [15–17]. The pH and temperature affect the surface charge of the adsorbent and degree of ionization of adsorbate species. The suggested mechanism of metal cations adsorption on hydrated metal oxides as SiO_2 is via both electrostatic interaction and formation of strong coordinate bonds between the cations and weakly acidic hydroxyl groups of the adsorbent [18]. It was thus of interest to study the adsorption behavior of metal cations from aqueous solutions on SiO_2 NP under different conditions such as temperature and pH.

To the best of our knowledge, no report was found in literature investigating the relation between metals adsorption on NPs materials used in pharmaceuticals preparations and their health hazardous consequences on patients.

SiO_2 NPs and its mixture with microcrystalline cellulose, MCC, were chosen as examples of commonly used nanomaterials as drug carrier in pharmaceutical preparations. Their metals adsorption behavior was tested in different conditions. SiO_2 is hygroscopic but absorbs large quantities of water without liquefying in acidic pH [19]. However, MCC is stable though hygroscopic material so it can be used as a modifier with SiO_2 at different pH and temperature solutions [19]. Although, the use of SiO_2 NP mixture with MCC can improve the excipient functionality [20], it is important to take into consideration their metal adsorption behavior [21,22]. The sources of metals in pharmaceutical preparations are water used as solvent for reconstitution of powder drugs, active or inactive ingredients and primary packaging materials. The aim of the work is to investigate the adsorption behavior of Pb, Ca, Mn, Mg and Zn on the surface of SiO_2 NP alone and its mixture with MCC powder (1:1). This was done at different temperature and pH values. Metal adsorption capability of the drug carrier was also tested in lab made pharmaceutical formulations. Flame atomic absorption (FAAS) method was used to analyze the remaining metal concentration after adsorption and it was fully validated.

2. Experimental

2.1. Materials

The metals standard solutions (1000 mg/L) used were of analytical grade: lead, zinc, manganese, calcium and magnesium as nitrate in HNO_3 0.5 mol/L (Merck – Darmstadt, Germany). SiO_2 NP 99.9%, with particle size 95% = 15 nm (Wacker Chemie – Pennsylvania, USA) and MCC with particle size 57.09% = 75 μm (Krishna – Mumbai, India) were used. Analytical grade reagents as Nitric acid 65% (POCH – Katowice, Poland) and Ammonia solution 33% w/w (Elnaser pharmaceutical chemical Co. – Cairo, Egypt) were used. The ingredients of Laboratory made pharmaceutical preparation were Cefprozil monohydrate with purity 99.7% (Qilu antibiotics pharmaceutical co. – Jinan, china), Aspartame with purity 99.05% (Changzhou Niutang chemical plant co. – Jiangsu, China), Erythrosine (F.D and C Red No.3 color) (Univar color – Downers Grove, England), Glycine with purity 100.38% (Alliance Bio Co. – Mumbai, China), Sucrose (Dakahlia for sugar – Dakahlia, Egypt), Strawberry flavor (Kamena products corporation – Talbia, Egypt), Sodium benzoate with purity 99.51% (Snow white chemical co. – Shanghai, China), Citric acid anhydrous with purity 99.9% (Erich Sasse – Hamburg, Germany). Polysorbate pre-mix, Simethicone – sucrose blend. Bi-distilled water was used through the study.

2.2. Instruments

Flame Atomic absorption Spectrometer AA240FS, Varian, serial No. AA1007M053 (Varian Inc.-parent company Agilent Technologies Inc. Santa Clara, CA 95051, United States) was used. The pH-

meter model was Jenway -3510, serial No.4255 (Barloworld Scientific Ltd., Dunmow, UK). Water bath (FALC Instruments – Via G. M. Compagnoni, 224047 Treviglio (BG) Italy) and the analytical balance, serial No. 1128230776 (Mettler Toledo, Switzerland/Vendor in Egypt address: LABIB DEMIAN YOUSSEF & CO. Cairo) were used.

2.3. Preparation of stock and standard solutions

A volume of 2 mL of each individual metal (Pb, Zn, Mg, Ca and Mn) stock standard solution (1000 mg/L) was diluted in 200 mL volumetric flask with 0.1 M nitric acid to give a standard solution of each metal with a concentration of 10 mg/L. Different volumes (5, 10, 20, 30 and 40 mL) of the final standard solution (10 mg/L) of each Pb, Ca and Mn were further diluted each in 100 mL volumetric flask with 0.1 M nitric acid to give working standard solutions of 0.5, 1, 2, 3 and 4 mg/L. Different volumes (2.5, 5, 10, 20 and 30 mL) of the final standard solution (10 mg/L) of each Zn and Mg were diluted each in 100 mL volumetric flask with 0.1 M nitric acid to give working standard solutions of 0.25, 0.5, 1, 2 and 3 mg/L. A standard solution (2 mg/L) of each individual metal was used as a standard test solution. For measurement of specificity, a standard test mixture (2 mg/L) of all investigated metals was prepared.

2.4. Metals adsorption and analysis procedures

2.4.1. Procedure of adsorption using SiO_2 NP

A volume of 100 mL nitric acid solution (0.1 M) was passed through a 250 mL separating funnel containing 5 g of SiO_2 NPs plugged with a piece of cotton at the end and then the filtrate collected was used as a blank when analyzing remaining metals in filtrate by flame atomic absorption (FAAS). The metal standard test solution (2 mg/L) of each metal was slowly passed through the wetted SiO_2 NP paste and the remaining metal in the filtrate collected was measured by FAAS. For estimating the remaining metal in filtrate, the prepared working standard solutions of each metal in the range mentioned in Table 1 were used to plot the calibration curve of each metal. Then, the regression equation obtained for each metal was used to estimate the remaining metal concentration in filtrate by (FAAS). This procedure was carried out for the standard test solution of each metal at different temperatures. This was done by adjusting the temperature of the standard test solution (2 mg/L) in a thermostated water bath at 25, 35, 45, 55 and 65 °C keeping the pH value of the solutions at 6 using 1 M ammonia solution. The concentration of adsorbed metal in mM of standard test solution (2 mg/L) was calculated at each temperature using the corresponding regression equation. After that the same procedure was repeated using different pH values of the metal standard test solution (2 mg/L) keeping the temperature at 25 °C. The pH of the solution was adjusted at 1.5, 3, 5, 7, 8, 9 and 11 with 1 M ammonia solution. The concentration of adsorbed metal in mM of standard test solution (2 mg/L) was calculated at each pH value at room temperature using the corresponding regression equation. The average concentration was recorded for triplicate determinations of each metal at each experimental condition with RSD < 2%. The conditions of FAAS method analysis are summarized in Table 1.

2.4.2. Procedure of adsorption using mixture of SiO_2 NP and MCC

The procedure described in Section 2.4.1 was carried out by using well mixed mixture of 5 g of SiO_2 NPs and 5 g MCC. The concentration of adsorbed metal in mM of standard test solution (2 mg/L) was calculated at each adjusted temperature and pH value using the proposed FAAS method.

Table 1
Flame Atomic absorption spectrometer conditions for Pb, Zn, Ca, Mg and Mn metals determination.

Conditions	Metal				
	Lead Pb	Zinc Zn	Calcium Ca	Magnesium Mg	Manganese Mn
Instrument type			Flame		
Concentration unit			(mg/L)		
Instrument mode			Absorbance		
Sampling mode			Manual		
Calibration mode			Concentration		
Wavelength	217.0 nm	213.9 nm	422.7 nm	285.2 nm	279.5 nm
Slit width	1.0 nm	1.0 nm	0.5 nm	0.5 nm	0.2 nm
Lamp current	10.0 mA	5.0 mA	1.0 mA	4.0 mA	5.0 mA
Flame type	Air/acetylene	Air/acetylene	Nitrous oxide/acetylene	Air/acetylene	Air/acetylene
Linearity range (mg/L)	0.5–4.00	0.25–3	0.5–4.00	0.25–3	0.5–4.00
Air flow	13.50 L/min		–	13.50 L/min	
Nitrous oxide flow	–		11.00 L/min	–	
Acetylene flow	2.00 L/min		6.35 L/min	2.00 L/min	

2.5. Application of the method using laboratory made drug formulation

2.5.1. Procedure of adsorption using drug formulation without drug carrier

To test whether the active or inactive ingredients other than the tested adsorbent materials could adsorb metals and interfere in the study, the procedure described in Section 2.4.1 was carried out by using the entire component in the drug formulation except for the SiO₂ NP and MCC. The drug formulation used was prepared by mixing a blend of 4.855 g of drug formulation contains 2.83 mg citric acid anhydrous, 11.58 mg sodium benzoate, 10 mg strawberry flavor, 4.147 g sucrose, 160 mg polysorbate pre-mix, 250 mg simethicone -sucrose blend, 5 mg aspartame, 5 mg sodium chloride, 258.53 mg cefoprozil monohydrate, 5 mg glycine and 0.5 mg Erythrosine color. As described, the concentration of adsorbed metal in mM of standard test solution (2 mg/L) on the surface of the mixture was calculated (n = 3) at each adjusted temperature and pH value. This was done by packing the prepared mixture in a 250 mL separating funnel plugged with a piece of cotton at the end, a volume of 100 mL nitric acid solution (0.1 M) was passed through it and the filtrate collected was used as a blank when analyzing remaining metals in filtrate by flame atomic absorption (FAAS). The metal standard test solution (2 mg/L) of each metal was slowly passed through the wetted drug formulation paste and the remaining metal in the filtrate collected was measured by FAAS. The remaining metal in filtrate was estimated as described under Section 2.4.1. This procedure was carried out at different temperatures and at different pH values of the metal standard test solution (2 mg/L).

2.5.2. Procedure of adsorption using drug formulation with drug carrier (SiO₂ NP)

The procedure described in Section 2.5.1 was carried out by using the same laboratory made drug formulation mentioned mixed with 25 mg SiO₂ NPs. The amount of SiO₂ NP used in the application is similar to the amount usually used in pharmaceutical dosage form. The concentration of adsorbed metal in mM of standard test solution (2 mg/L) on the surface of the mixture was calculated (n = 3) at each adjusted temperature and pH value.

2.5.3. Procedure of adsorption using drug formulation with drug carrier (SiO₂ NP and MCC mixture)

The procedure described in Section 2.5.1 was carried out by using the same laboratory made drug formulation mentioned mixed with 120 mg MCC and 25 mg SiO₂ NPs. The amounts of SiO₂ NP and MCC were different than the used in section of Section 2.4 to be the same as the amounts used in the pharmaceutical dosage form used in the study. The concentration of adsorbed metal in mM of the metal standard test solution (2 mg/L) on the surface of the mixture was calculated (n = 3) at each adjusted temperature and pH value.

3. Results and discussion

### 3.1. Effect of different parameters on adsorption behavior of drug carriers

3.1.1. Effect of temperature

Upon studying the metals adsorption behavior either of SiO₂ NPs alone or mixture of SiO₂ NPs and MCC (1:1) as drug carriers, it was noticed that the concentration of adsorbed metal increased with the increase in temperature from 25 °C to 65 °C nearly in a linear relation. This may be attributed to the increase of the adsorbent surface area with increasing the temperature [17]. The amount of adsorbed metal differs with the different type of metals used in the study. The maximum adsorption was achieved with magnesium, calcium and manganese metals at 65 °C, Fig. 1. However, at each studied temperature, the amount of adsorbed metal was different as the adsorbed metal amount by 5 g SiO₂ NPs mixture with 5 g MCC (10 g total adsorption mixture) was slightly higher than that of 5 g SiO₂ NP alone. This may be attributed to the fact that MCC itself possesses an adsorption capacity [21–24].

3.1.2. Effect of pH

The effect of metal solution pH on the adsorption behavior of the drug carriers was also investigated.

The concentration of adsorbed metal increased with the increase of the pH values in nearly linear relation till pH 8. This could be explained that at low pH, large number of protons are available in solution and can compete with metal cations for the adsorption sites on the drug carrier nanoparticles. Also, the surface of adsorbent will be associated with hydronium ion (H₃O⁺). As a result, the surface will maintain a net positive charge preventing the access of positivity charged metals ions. As the pH increases, the positive charge on the sorbent surface will gradually decrease. Thus, reduces the repulsion between sorbent surface and cations [15–17]. At pH 9, the adsorbed amount was nearly constant, followed by a slight decrease with the increase in the pH of the solution. However at pH greater than 10.7, a total loss of the SiO₂ NP ability to adsorb metals was noticed, as SiO₂ is dissolved at this pH to form silicates. The maximum adsorption was achieved with magnesium, calcium and manganese metals at pH 8, Fig. 2. Nearly the same results were obtained upon investigating the adsorption behavior of metals on mixture of SiO₂ NPs and MCC (1:1) at differ-

a

b

c

d

e
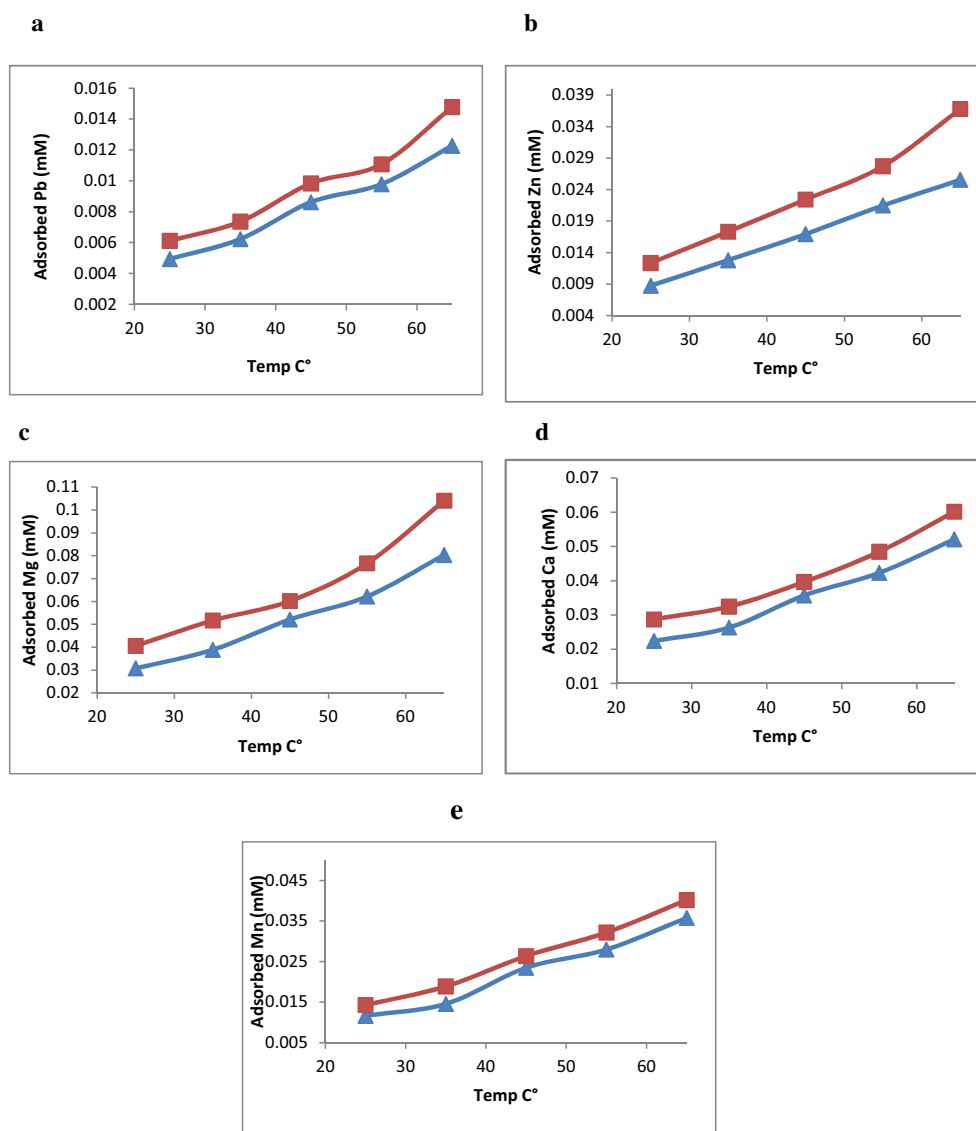
Fig. 1. Adsorbed metals, Pb, Zn, Mg, Ca and Mn (a, b, c, d, e) amount percent after passing the standard test solution (2 mg/L) of each metal through 5 g silicon dioxide NPs (━▲━) and through mixture 1:1 silicon dioxide NPs with microcrystalline cellulose (5 g each) (━■━) at different temperature.

ent pH values. The maximum adsorption was achieved with magnesium, calcium and manganese metals at pH 8, Fig. 2.

3.1.3. Adsorption capacity

The adsorption capacity is an important factor, because it determines how much of metal ions from solution can be adsorbed by a certain amount of adsorbent [25]. In the present study, the amounts used of SiO_2 NP and its mixture with MCC were 5 g and 10 g, respectively, so it is important to calculate the adsorption capacity (metal adsorbed in mg per gram unit of adsorbent material) to estimate the material which possess the higher adsorption capacity. The adsorption capacity of SiO_2 NPs and SiO_2 NPs mixture with MCC (1:1) was calculated at the maximum pH and temperature of adsorption. This was done according to the following formula:

$$Qe = \frac{[(C_0 - Ce) \times V}{m}$$

(1)

where:

Qe is adsorption capacity (mg/g).

C_0 and Ce are the initial and the residual concentrations of metal ion in aqueous phase (mg/L), respectively, V is the volume of the aqueous phase (L) and m is the mass of adsorbent used (g).

The results presented in Table 2 indicate that the capacity of SiO_2 NPs alone is considerably higher than that of mixture SiO_2 NPs with MCC in a ratio 1:1. This may be attributed to the high surface area of SiO_2 NPs (200 ± 25 m^2/g) compared to that of MCC. This indicates that the adsorption capacity of SiO_2 NP is decreased when mixed with MCC which decrease its ability to adsorb and concentrate metals. Consequently, decrease any possible risk of metal toxicity.

3.2. Validation of the method of analysis

The FAAS method for analysis of remaining metals after adsorption was validated according to USP guidelines [26].

a

b

c

d

e
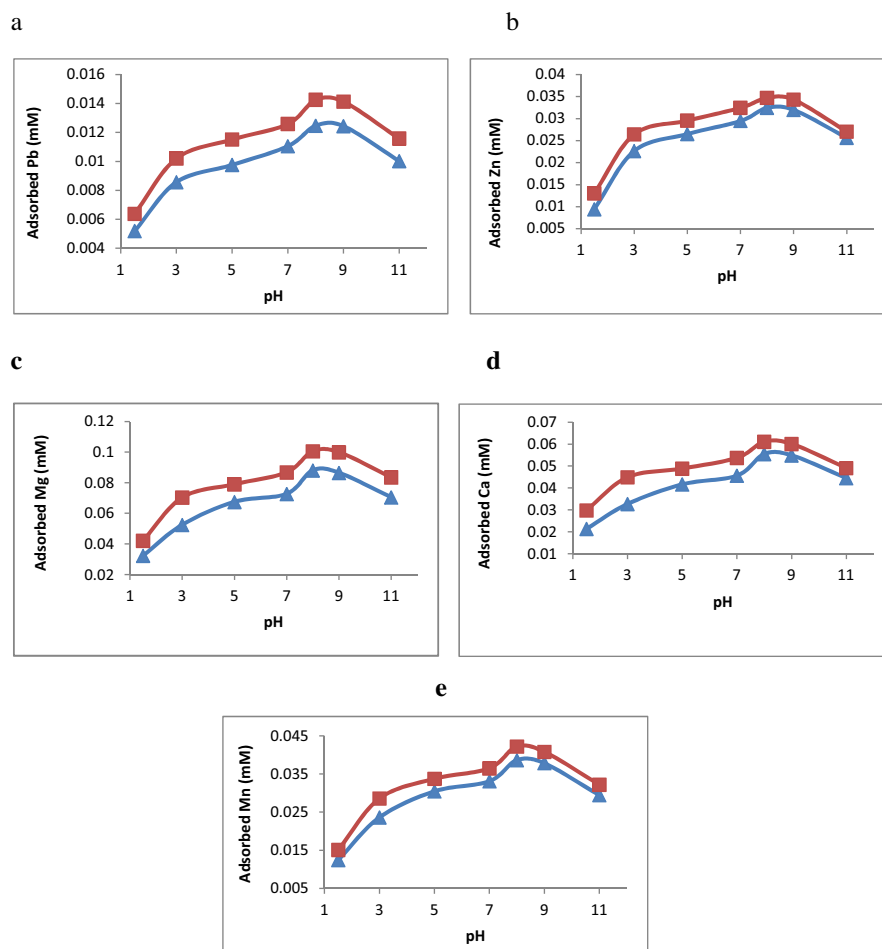
Fig. 2. Adsorbed metals, Pb, Zn, Mg, Ca and Mn (a, b, c, d, e) amount percent after passing the standard test solution (2 mg/L) of each metal through 5 g silicon dioxide NPs (—▲—) and through mixture 1:1 silicon dioxide NPs with microcrystalline cellulose (5 g each) (—■—) at different pH values.

Table 2
Comparison of adsorption capacity (mg/g) between silicon dioxide NPs and SiO$_2$ NPs mixture with microcrystalline cellulose (1:1).

Parameter [A]	Adsorbent	Adsorption capacity (mg/g)				
		Pb	Zn	Mg	Ca	Mn
pH 8	SiO$_2$ NPs	0.2043	0.1948	0.2114	0.2220	0.2068
	SiO$_2$ NPs + MCC	0.1169	0.1041	0.1207	0.1222	0.1054
Temp 65 °C	SiO$_2$ NPs	0.2012	0.1534	0.1927	0.2086	0.1788
	SiO$_2$ NPs + MCC	0.1212	0.1104	0.1248	0.1204	0.1004

[A] The adsorption experiment was conducted at the parameters of maximum metals adsorption (maximum adsorption at pH value of 8 keeping temperature at 25 °C while maximum adsorption at temperature of 65 °C keeping pH at 6).

Table 3
Different linearity parameters for metals determination by the proposed method of analysis (FAAS).

Metal	r [A]	a [B]	b [C]	$S_{y/x}$ [D]	S_a [E]	S_b [F]	F [G]	LOD [H]	LOQ [I]
Pb	0.9999	-0.29×10^{-3}	19.23×10^{-3}	0.35×10^{-3}	0.31×10^{-3}	0.12×10^{-3}	25,290	0.0540	0.1800
Zn	0.9999	2.28×10^{-3}	350.43×10^{-3}	0.30×10^{-2}	0.23×10^{-2}	0.13×10^{-2}	69,297	0.0259	0.0866
Mg	0.9999	-1.71×10^{-3}	602.91×10^{-3}	0.12×10^{-2}	0.91×10^{-3}	0.53×10^{-3}	1,279,235	0.0060	0.0201
Mn	0.9998	-0.16×10^{-3}	98.79×10^{-3}	0.26×10^{-2}	0.22×10^{-2}	0.91×10^{-3}	11,742	0.0792	0.2642
Ca	0.9998	-0.71×10^{-3}	60.90×10^{-3}	0.14×10^{-2}	0.12×10^{-2}	0.50×10^{-3}	14,904	0.0703	0.2345

[A] Correlation coefficient.
[B] Intercept.
[C] Slope.
[D] Standard deviation of residuals.
[E] Standard deviation of intercept.
[F] Standard deviation of slope.
[G] Variance ratio, equals the mean of squares due to regression divided by the of squares about regression (due to residuals).
[H] Limit of detection (mg/L).
[I] Limit of quantitation (mg/L).

Table 4

Accuracy and precision of concentration level 0.5 mg/L of each metal spiked with filtrate after passing through 5 g silicon dioxide NPs at each studied temperature as representative example.

Metal	Metal recovery %[A] ± RSD%				
	Temp. °C				
	25 °C	35 °C	45 °C	55 °C	65 °C
Pb	98.4 ± 0.07	98.98 ± 0.22	98.74 ± 0.08	99.16 ± 0.32	98.98 ± 0.44
Zn	98.2 ± 0.33	99 ± 0.66	98.8 ± 0.09	99.2 ± 0.40	99.38 ± 0.81
Mg	98.3 ± 0.31	98.4 ± 0.50	98.98 ± 0.61	99 ± 0.07	98.94 ± 0.31
Ca	98.2 ± 0.33	99.02 ± 0.19	98.94 ± 0.18	98 ± 0.41	98.96 ± 0.18
Mn	98.96 ± 0.61	99.16 ± 0.81	98.8 ± 0.72	98.8 ± 0.54	98.96 ± 0.61

[A] The accuracy of the standard metal added amount (0.5 mg/L) to the filtrate of metals mixture (2 mg/L) passed through 5 g SiO_2 NPs% ± RSD% (n = 3).
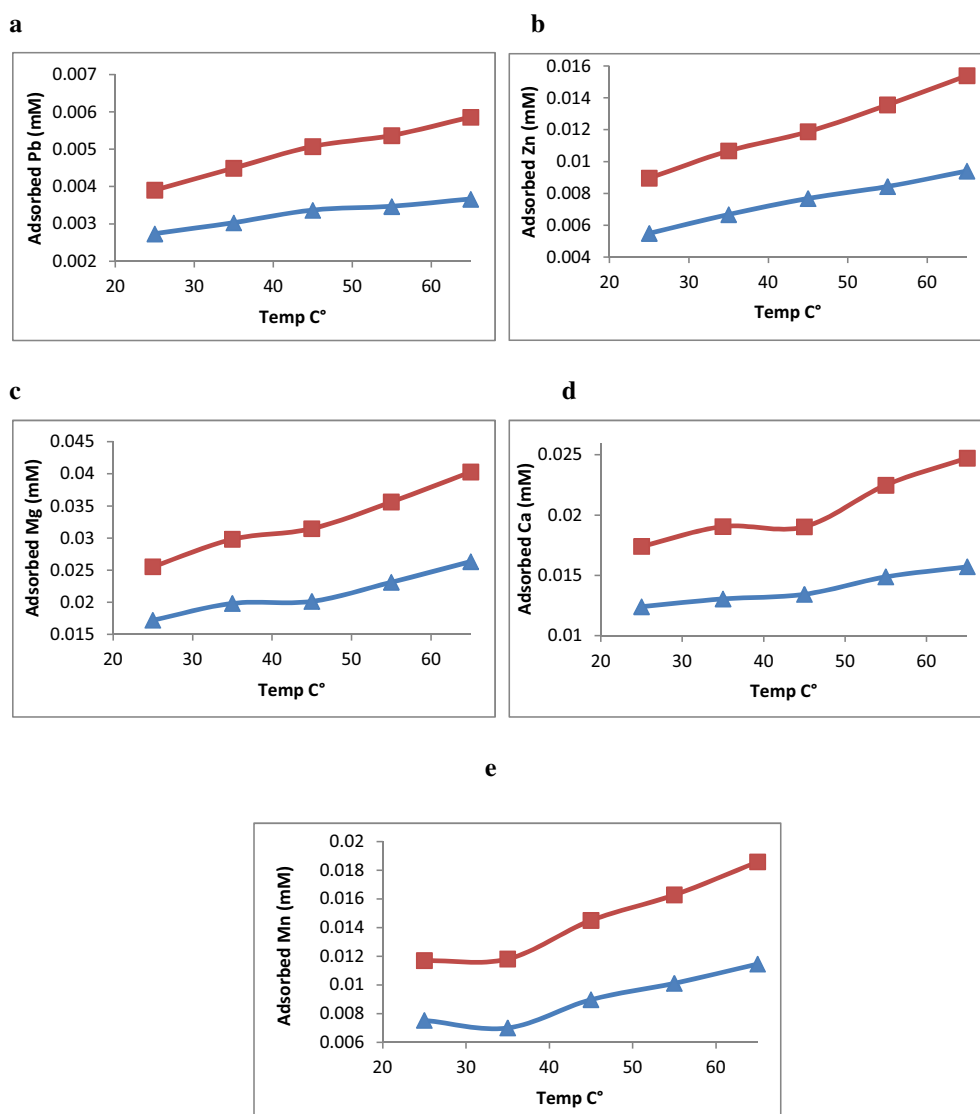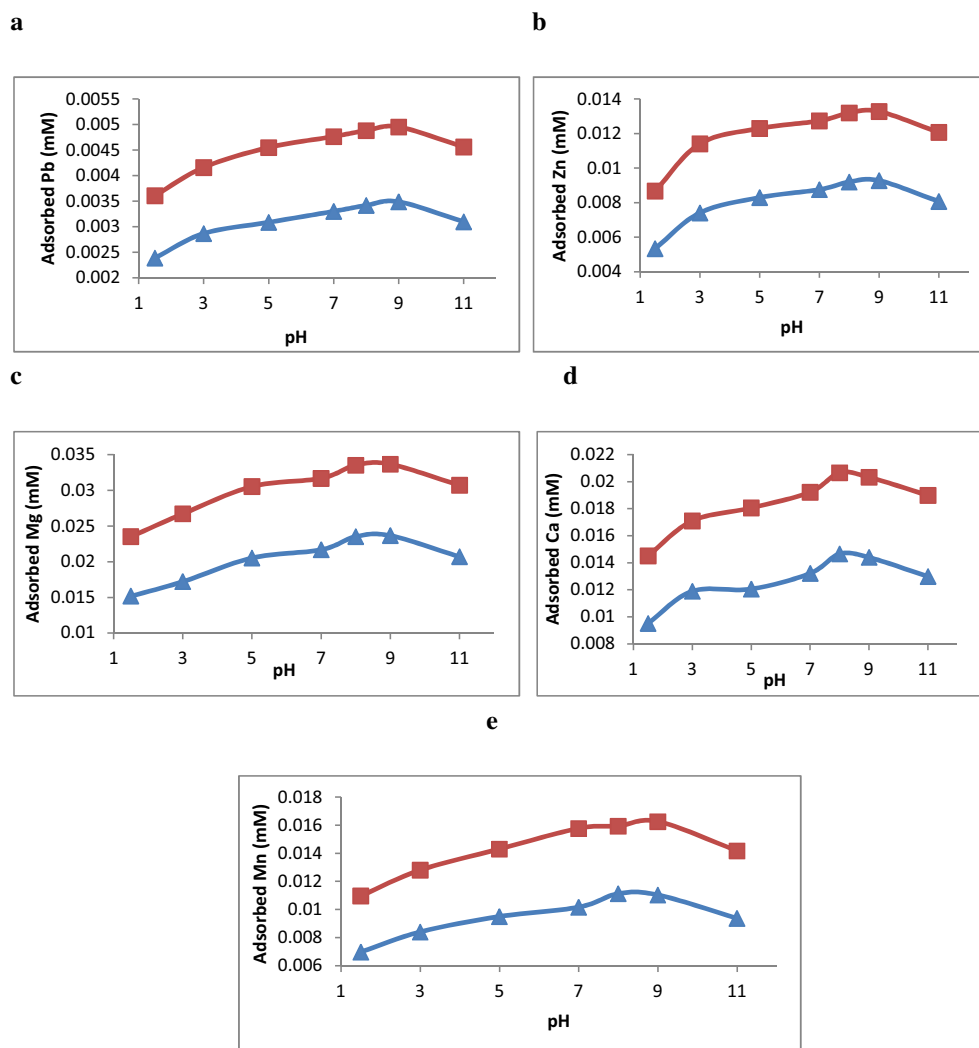

Fig. 3. Adsorbed metals, Pb, Zn, Mg, Ca and Mn (a, b, c, d, e) amount percent after passing the standard test solution (2 mg/L) of each metal through drug formulation mixture containing 25 mg silicon dioxide NPs (△) or 25 mg silicon dioxide NPs with 120 mg microcrystalline cellulose (■) at different temperature.

3.2.1. Linearity

The linearity procedures for quantitative determination of metals traces were followed. The linearity as one of the validation parameters is the relationship between serial diluted concentrations of metals and their corresponding absorbance at suitable wavelength (λ) for each metal in the ranges stated in Table 1. Different regression parameters were calculated for the studied metals and presented in Table 3. The high values of correlation coefficient (r) and variance ratio (F) with low values of intercept (a) and standard deviation of residuals ($S_{y/x}$) indicate the good linearity of the calibration graphs [27].

Fig. 4. Adsorbed metals, Pb, Zn, Mg, Ca and Mn (a, b, c, d, e) amount percent after passing the standard test solution (2 mg/L) of each metal through drug formulation mixture containing 25 mg silicon dioxide NPs (━▲━) or 25 mg silicon dioxide NPs with 120 mg microcrystalline cellulose (━■━) at different pH values.

3.2.2. Limit of detection (LOD) and Limit of quantitation (LOQ)

LOD and LOQ were calculated according to Miller [28] and low values were obtained as stated in Table 3.

3.2.3. Accuracy and precision

In order to test accuracy and precision of the presented method, the recovery % ± RSD% was calculated using standard addition method at three concentration levels (0.5, 1, 2 mg/L) of each metal spiked with the filtrate obtained after eluting metals mixture solution (2 mg/L). The spiking procedure used in evaluating accuracy and precision for each metal showed no evidence of interference from other metals.

The calculated recovery % ± RSD% of different spiked metals was within the accepted range (98–102%) and the relative standard deviation values were less than 2%, Table 4. The accuracy and precision were evaluated using the two types of drug carriers (SiO$_2$ NPs alone and its mixture with MCC) at different temperature and pH values. Table 4 is a representative example of accuracy and precision evaluation at 0.5 mg/L concentration level using SiO$_2$ NPs at different temperature.

3.2.4. Specificity

In order to test specificity of the proposed method, each metal was detected in the filtrate of metals mixture standard solution (2 mg/L) after passing through different adsorbent materials. This was done using the specified hollow cathode lamp for each metal to provide its own λ of absorbance. Each metal was detected without interference from other metals in the mixture.

3.3. Application of the method using laboratory made drug formulation

For the drug formulation with no drug carriers, no adsorbed metals were detected at each temperature and pH value. In presence of SiO$_2$ NPs as drug carrier alone or using the mixture of SiO$_2$ NPs and MCC in drug formulation, the metals adsorbed amount increased with the increase of the temperature from 25 °C to 65 °C in linear relation. As can be seen in Fig. 3, the different types of metals showed different adsorption behavior. Also, the same effect of pH on the adsorption behavior of drug carriers was obtained as discussed previously, Fig. 4. The maximum adsorption was also recorded with magnesium, calcium and manganese metals.

4. Conclusion

Presence of nanoparticles materials in dosage forms can lead to concentrate metals on their surface through adsorption phe-

nomenon. This could be critical especially in cases of traces of metals are present in water for reconstitution, active, inactive ingredients or primary packaging materials. Nanoparticles drug carriers have great advantages but they should be used with caution as a result of their adsorption of metals and possible concentration of these metals impurities in pharmaceutical preparations. Hence, the risk of metal toxicity may increase. The present study investigates the adsorption behavior of metals on different nanoparticles drug carrier. Effect of different metals solutions pH and temperature on the adsorption efficiency was investigated. It was found that upon increasing the temperature, the ability of the adsorbent material increases. The pH of the metal solution has the same effect as temperature till pH 8. However, above pH 8 the adsorbent material began to lose its adsorption efficiency. The adsorption capacity was measured for each drug carrier at the recorded pH and temperature of maximum adsorption. It was found that the adsorption capacity of mixture of MCC and SiO_2 NPs was less than SiO_2 NPs alone. As a result, MCC is recommended to be used with SiO_2 NPs as additive in pharmaceuticals not only because the enhancement in excipients functionality but also because it lowers the metal adsorption capacity of SiO_2 NPs. A validated flame photometric method was used for determination of metal remaining after adsorption. Also, application of the proposed method was done using laboratory made pharmaceutical preparation containing nanoparticles drug carriers.

Conflict of interest

None declared.

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