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Verifying the Ranking System of Nanoparticles in the Industry Based upon AHP Technique

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ABSTRACT

In this research, 6 groups which concluded of 4 nanoparticles (Metallic nanoparticles, ceramic nanoparticles, polymeric nanoparticles and semiconductor nanoparticles) and composites and nanocomposites are verified. These groups are used in industrial applications for increasing their effectiveness. With attention to different criteria which are both qualitative and quantitative, choosing the most suitable group is of great importance. In this research, we must verify the method of ranking and choosing the appropriate group by using AHP technique and the view of the experts of this industry. These criteria are selectivity, active surface, effectiveness, stability, the behavior in the medium, corrosion resistance, measurement easiness, production easiness, environmental pollution and economical profit. Results of this research show that with attention to all criteria for using in pharmacological and medical process, the most suitable group is ranked in this position: nanocomposite, nanosemiconductor, composite, nanopolymeric, nanoceramic and nanometallic.

KEYWORDS: nanocomposites, nanoparticles, AHP technique, rating, qualitative and quantitative criteria, industry

1. INTRODUCTION

As we know, any new phenomenon has different positive and negative effects, Then we can conclude the group choice methods for using in industry, that are very considerable, because of the human being health and also their effectiveness. Nevertheless, therefore, some different quantitative and qualitative criteria for distinguishing the dominance of a method towards the others, which any of them may have different importance. In any case any nanoparticle have some advantages in some particular criteria. In this circumstances, the problem of the choice of nanoparticles should be converted and solved into a mathematical model. One of the most appropriate is using the AHP technique, which will be explained briefly in the other section of the paper.

A nanoparticle, is a particle which it's dimension is about 1-100 nm. Nanoparticles contain the combinational nanoparticles such as the 2 layer nuclear structures besides the metallic, insulators and semiconductor types. Nanoparticles are considered in lower sizes of nanoparticles. Also, nanospheres, nonorods and nanocupes are considered as shapes of nanoparticles. nanocrystals and semiconductor quantum points are considered as subsets of nanoparticles. These nanoparticles have some applications in electronical, electrical and biomedical fields as drug career and photographic agents.

Also because of many active sites and planar area, the nanocomposits create important modification in activity, selectivity, efficiency and stability (useful age) towards the traditional heavy materials. Composits production by carriers (such as Alumin) is done with the aim of erecting the active and vast surface.

On the other hand, one of the other preference of the production of nanocomposits towards the traditional composits is based upon this fact that no direct synthesis method is for some cheap materials with vast surface and valuable economical such as transitional metals Carbides and Nitrides, traditionally.

Some signs showing the selective activity of catalysts bring us up to this subject that water molecule activates the oxidizing reaction of carbon monoxide catalytically.

Nanotechnology has many applications in electronics, medicinal, pharmacological industries and etc. In fact, the birth of this field is aligned with the famous lecture of "Richard Feynman", the famous professor in physics in California institute of Technology and his famous sentences: "there's plenty of room at the bottom" [1].

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But, the new properties created from the displacement of atoms in this scale, brings up several questions such as manufacturing, consumption, health and environment setup some dangers for human being in the manufacture, using, and repelling steps?

Despite after more than 10 years from being sent the first nanomaterials to market and increasing application of this technology in industry, there are low information about it's dangerous effects for environment, health and industries safety [2].

Maybe when these materials were produced for sending to market, nearly nobody noticed their hazardous properties for the health of human and environment, while some studies which being performed upon the biological reactions of some nanomaterials, showed that many nanoparticles affect upon the organisms of our body by breaking the layers [2]. Also they can affect our body by breathing, eating and skin and finally jetting into the blood. In recent years, the governments have wanted the governmental and nongovernmental, industrials and nonindustrial institutes to verify the health and environmental safety subjects and minimizing their dangerous effects.

1.1. AHP method

Multi criteria decision making is one field of "OR" and "management sciences" which is developed with attention to the different applied necessities in the last decade rapidly. "decision making" is a method for finding the best choice among a set of some present choices. When we consider different criteria, we can name this method as "MCDM" (multi criteria decision making). AHP technique is one of these methods and has a vast and successful usage in many "DM" problems [3,4].

In AHP method, first calculate the ration between criteria weight and the total value of any choice is calculated as the obtained weight [5,6]. In comparison on with the other methods of MCDM, AHP is the most successful one [7]. Fei and his cooperators used AHP for choosing a successful environmental management system in 2008.

After making all of the matrixes of even comparisons between the criteria and sub criteria, "CR" should be calculated.CI shows deviation from compromise [5]. If the obtained CR is lower than 0.1, the comparisons are acceptable and otherwise we should perform the comparisons with more information and more accurate by experts once again.

1.1.1. the principles of AHP

Thomas Saaty (the founder of this method) has explained four principles as the main ones. These principles are [8]:

1- The reciprocal condition: if preference of element A upon element B is n, then preference of element B upon element A will be 1/n.
2- The identity principle: element A should be homogenous and comparisonable with element B. in other words, the preference element A upon element B cannot be infinitive or zero.
3- dependence: any element can be dependent to its higher level elements and in the linear form, this dependence can continue to the highest level.
4- expectations: whenever the changes are created in the AHP method, the verifying process should be done once again.

1.1.2. the AHP process model

Applying this method is based upon the 4 main steps:

1- Modeling

In this step, the DM aim and problem is changed into a hierarchy system of decision elements which are related together. The decision elements are "DM criteria", and "decision choices". The AHP process needs the wreckage of a problem with several criteria and ringing it into a hierarchy system of levels.

The high level explains the main aim of DM process. The second level, shows the main criteria which maybe branched into the partial criteria in the next layer. The last layer presents decision choices [8].

2- Preferable judgment (even comparisons)

Performing some comparisons among the different choices of decision, based upon any criteria judging about the importance of decision criteria with doing the even comparisons, is acted after the planning of hierarchy system of decision problem.

The person who decides should make the matrix series which measures the relative preference or importance of criteria numerically towards together and any decision choice with attention to criteria towards the other choices.

3- Calculations of the relative weights

Defining the weight of "decision elements" towards together is done by a set of numerical calculations for defining the priority of any decision element is necessary and this will be done by using the information of matrixes of even comparisons.

4- Combining the relative weights

In this step, we should multiply the relative weight of any element into the higher elements weight for getting the final weight. This work is done for ranking the decision choices. By doing this step for any choice, the final weight value is obtained

2. The research procedure

This research is applied from the target's view and is descriptive- exploring from the researchers' view. In this way, the necessary information obtained by using the library method. Then, AHP technique which is one of DM methods was used. In this research, first one answer sheet was prepared with 10*10 dimensions containing the criteria even comparisons towards together and was transferred to the nanoscientists. Also, 10 other answer sheets were completed in relation with any 10 criteria about the chosen even comparisons by them. Then, any matrixes converted into a normalized matrix and averaging was done.

The groups (choices) weight towards any criteria was multiplied by criteria weight vector. The value of any group calculated for using in industry.

2.1. Modeling the problem

In this research, our aim is solving the problem of defining one of the 6 groups which are: composites, nanocomposites, metallic nanoparticles, ceramic nanoparticles, polymeric nanoparticles and semiconductor nanoparticles, and these groups are used in industry with attention to quantitative and qualitative criteria containing selectivity, active surface, effectiveness, stability, the behavior in the medium, corrosion resistance, measurement easiness, production easiness, environmental pollution and economical profit. For these reasons, we use AHP decision making method. After gathering the initial information, based upon the principles of this method, we can define the solution of the problem. In the next section, we explain the solution steps in detail.

2.2. ranking nanoparticles and composites

For choosing a group, with respect to qualitative and quantitative criteria, we must make logical decisions. Therefore, by using the AHP model and the view of experts in this industry, even comparisons matrix is prepared. After normalizing and verifying the compromising matrixes and passing the calculating steps, the importance of any group is defined for applying in industry. For this purpose, first the even comparisons matrix is prepared and as an answer sheet has been given to experts of this industry and they voted about the preference of parameters towards together.

For solving the problem, in the first step parameter even comparisons matrix is prepared and in the second step, the normalized even comparisons matrix and the importance of different groups is calculated. In this step, we use the following relations. If the criteria has a positive role, is normalized with relation (1) and if it has a negative role, is normalized with relation (2). Meanwhile, if the criteria is quantitative, then, there is no need for the formation of even comparisons matrix. Then, we gain the mean in rows (Aij).

$P_{ij} = X_{ij} / \sum X_{kj}$ (k=1 to m) (1)

$P_{ij} = 1- (X_{ij}/X_j max)$ (2)

Xij: the given value to the i^{th} choice with respect to j^{th} criteria

Pij: the normalized value of the Xij

In the third step, the whole score of any group is calculated with respect to different agents such as selectivity, active surface, effectiveness, stability, and etc., based upon the relation (3).

$A_i= A_{ij} *C$ (3)

Ai: the vector of importance (weight) of choices.

Aij: the weight matrix of any i^{th} choice in relation with j^{th} criteria.

C: the calculated vector of criteria weight

3. RESULTS AND DISCUSSION

With respect to the calculated weight for any group (choice), we can decide about the most suitable group. Taken results based upon the used procedure are reflected in these tables:

Table 1- comparison of criteria towards together from the experts' view

criteria	selectivity	Active sur.	effectiveness	stability	behavior	resistance	measuring easiness	production easiness	pollution	economical profit
selectivity	1	3	2	0.33	2	0.2	0.33	0.5	0.25	0.33
Active sur.	0.33	1	0.5	0.33	0.5	0.14	0.25	0.33	0.17	0.25
effectiveness	0.5	2	1	0.33	4	0.17	3	4	0.25	0.33
stability	3	3	3	1	7	0.33	4	6	3	0.5
behavior	0.5	2	0.25	0.14	1	0.13	0.25	0.5	0.14	0.14
resistance	5	7	6	3	8	1	9	9	7	3
production easiness	3	4	0.33	0.25	4	0.11	1	2	0.2	0.25
measuring easiness	2	3	0.25	0.17	2	0.11	0.5	1	0.13	0.14
pollution	4	6	4	0.33	2	0.14	5	8	1	2
economical profit	3	4	3	2	7	0.33	4	7	0.5	1

Table 2- the normalized matrix for comparing the parameters towards together and calculating the criteria weight

criteria	selectivity	Active sur.	effectiveness	stability	behavior	resistance	measuring easiness	production easiness	pollution	economical profit	Criteria Weight
selectivity	0.044783	0.085714	0.098377	0.041878	0.053333	0.075188	0.012075	0.013045	0.019778	0.041562	0.048573
Active sur.	0.014778	0.028571	0.024594	0.041878	0.013333	0.052632	0.009147	0.008609	0.013449	0.031486	0.023848
effectivness	0.022391	0.057143	0.049188	0.041878	0.106667	0.06391	0.109769	0.104357	0.019778	0.041562	0.061664
stability	0.134348	0.085714	0.147565	0.126904	0.186667	0.12406	0.146359	0.156535	0.237342	0.062972	0.140847
behavior	0.022391	0.057143	0.012297	0.017766	0.026667	0.048872	0.009147	0.013045	0.011076	0.017632	0.023604
resistance	0.223914	0.2	0.29513	0.380711	0.213333	0.37594	0.329308	0.234803	0.553797	0.377834	0.318477
production easiness	0.134348	0.114286	0.016232	0.031726	0.106667	0.041353	0.03659	0.052178	0.015823	0.031486	0.058069
measuring easiness	0.089566	0.085714	0.012297	0.021574	0.053333	0.041353	0.018295	0.026089	0.010285	0.017632	0.037614
pollution	0.179131	0.171429	0.196754	0.041878	0.053333	0.052632	0.182949	0.208714	0.079114	0.251889	0.141782
economical profit	0.134348	0.114286	0.147565	0.253807	0.186667	0.12406	0.146359	0.182625	0.039557	0.125945	0.145522

Table 3- the normalized matrix for comparison of groups from the view of **selectivity** qualitative criteria and calculating the weight of these criteria

group	composite	nanocomposite	metallic	ceramic	polymeric	semiconductor	Weight
composite	0.090909	0.106838	0.125	0.097561	0.054054	0.080882	0.092541
nanocomposite	0.363636	0.42735	0.3125	0.341463	0.432432	0.490196	0.394596
metallic	0.045455	0.08547	0.0625	0.02439	0.054054	0.061275	0.055524
ceramic	0.045455	0.059829	0.125	0.04878	0.027027	0.041667	0.05796
polymeric	0.181818	0.106838	0.125	0.195122	0.108108	0.080882	0.132961
semiconductor	0.272727	0.213675	0.25	0.292683	0.324324	0.245098	0.266418

Table 4- the normalized matrix for comparison of groups from the view of **active surface** qualitative criteria and calculating the weight of these criteria

group	composite	nanocomposite	metallic	ceramic	polymeric	semiconductor	Weight
composite	0.10917	0.081633	0.142857	0.171429	0.189036	0.121359	0.135914
nanocomposite	0.545852	0.408163	0.285714	0.228571	0.283554	0.485437	0.372882
metallic	0.036026	0.069388	0.047619	0.028571	0.023629	0.048544	0.042296
ceramic	0.036026	0.102041	0.095238	0.057143	0.031191	0.041262	0.060484
polymeric	0.054585	0.134694	0.190476	0.171429	0.094518	0.06068	0.11773
semiconductor	0.218341	0.204082	0.238095	0.342857	0.378072	0.242718	0.270694

Table 5- the normalized matrix for comparison of groups from the view of **effectiveness** qualitative criteria and calculating the weight of these criteria

group	composite	nanocomposite	metallic	ceramic	polymeric	semiconductor	Weight
composite	0.138075	0.138075	0.103448	0.134348	0.175131	0.125313	0.135732
nanocomposite	0.418994	0.41841	0.241379	0.268697	0.350263	0.501253	0.366499
metallic	0.046089	0.058577	0.034483	0.014778	0.014886	0.027569	0.03273
ceramic	0.046089	0.07113	0.103448	0.044783	0.021891	0.032581	0.053321
polymeric	0.069832	0.104603	0.206897	0.179131	0.087566	0.062657	0.118447
semiconductor	0.27933	0.209205	0.310345	0.358262	0.350263	0.250627	0.293005

Table 6- the normalized matrix for comparison of groups from the view of **stability** qualitative criteria and calculating the weight of these criteria

group	composite	nanocomposite	metallic	ceramic	polymeric	semiconductor	Weight
composite	0.136426	0.156398	0.111111	0.098377	0.173913	0.097276	0.128917
nanocomposite	0.409277	0.473934	0.333333	0.344319	0.434783	0.583658	0.429884
metallic	0.04502	0.052133	0.037037	0.016232	0.021739	0.027237	0.033233
ceramic	0.068213	0.066351	0.111111	0.049188	0.021739	0.033074	0.058279
polymeric	0.068213	0.094787	0.148148	0.196754	0.086957	0.064202	0.109843
semiconductor	0.272851	0.156398	0.259259	0.29513	0.26087	0.194553	0.239844

Table 7- the normalized matrix for comparison of groups from the view of **behavior** qualitative criteria and calculating the weight of these criteria

group	composite	nanocomposite	metallic	ceramic	polymeric	semiconductor	Weight
composite	0.151745	0.202429	0.25	0.204082	0.296296	0.083123	0.197946
nanocomposite	0.30349	0.404858	0.285714	0.285714	0.37037	0.503778	0.358988
metallic	0.021244	0.052632	0.035714	0.020408	0.018519	0.042821	0.03189
ceramic	0.030349	0.05668	0.071429	0.040816	0.018519	0.035264	0.042176
polymeric	0.037936	0.080972	0.142857	0.163265	0.074074	0.083123	0.097038
semiconductor	0.455235	0.202429	0.214286	0.285714	0.222222	0.251889	0.271963

Table 8- the normalized matrix for comparison of groups from the view of **resistance** qualitative criteria and calculating the weight of these criteria

group	composite	nanocomposite	metallic	ceramic	polymeric	semiconductor	Weight
composite	0.137363	0.104712	0.172414	0.172043	0.205761	0.301205	0.18225
nanocomposite	0.686813	0.52356	0.310345	0.344086	0.48011	0.451807	0.46612
metallic	0.027473	0.057592	0.034483	0.010753	0.022634	0.021084	0.029003
ceramic	0.034341	0.068063	0.137931	0.043011	0.017147	0.025602	0.054349
polymeric	0.04533	0.073298	0.103448	0.172043	0.068587	0.049699	0.085401
semiconductor	0.068681	0.172775	0.241379	0.258065	0.205761	0.150602	0.182877

Table 9- the normalized matrix for comparison of groups from the view of **measuring easiness** qualitative criteria and calculating the weight of these criteria

group	composite	nanocomposite	metallic	ceramic	polymeric	semiconductor	Weight
composite	0.195313	0.148649	0.1875	0.235849	0.32	0.301205	0.231419
nanocomposite	0.585938	0.45045	0.21875	0.283019	0.32	0.451807	0.384994
metallic	0.033203	0.063063	0.03125	0.009434	0.0136	0.021084	0.028606
ceramic	0.039063	0.076577	0.15625	0.04717	0.0264	0.025602	0.061844
polymeric	0.048828	0.112613	0.1875	0.141509	0.08	0.049699	0.103358
semiconductor	0.097656	0.148649	0.21875	0.283019	0.24	0.150602	0.189779

Table 10- the normalized matrix for comparison of groups from the view of **production easiness** qualitative criteria and calculating the weight of these criteria

group	composite	nanocomposite	metallic	ceramic	polymeric	semiconductor	Weight
composite	0.112233	0.110619	0.153846	0.147565	0.207612	0.085938	0.136302
nanocomposite	0.448934	0.442478	0.269231	0.29513	0.346021	0.520833	0.387104
metallic	0.028058	0.061947	0.038462	0.016232	0.013841	0.036458	0.0325
ceramic	0.037037	0.075221	0.115385	0.049188	0.017301	0.044271	0.056401
polymeric	0.037037	0.088496	0.192308	0.196754	0.069204	0.052083	0.10598
semiconductor	0.3367	0.221239	0.230769	0.29513	0.346021	0.260417	0.281713

Table 11- the normalized matrix for comparison of groups from the view of **pollution** qualitative criteria and calculating the weight of these criteria

group	composite	nanocomposite	metallic	ceramic	polymeric	semiconductor	Weight
composite	0.131234	0.111111	0.2	0.224719	0.321285	0.115207	0.183926
nanocomposite	0.524934	0.444444	0.266667	0.269663	0.401606	0.460829	0.394691
metallic	0.02231	0.057778	0.033333	0.011236	0.016064	0.039171	0.029982
ceramic	0.026247	0.075556	0.133333	0.044944	0.02008	0.039171	0.056555
polymeric	0.032808	0.088889	0.166667	0.179775	0.080321	0.115207	0.110611
semiconductor	0.262467	0.222222	0.2	0.269663	0.160643	0.230415	0.224235

Table 12- the normalized matrix for comparison of groups from the view of **economical profit** qualitative criteria and calculating the weight of these criteria

group	composite	nanocomposite	metallic	ceramic	polymeric	semiconductor	Weight
composite	0.233645	0.196078	0.16129	0.179775	0.240964	0.362319	0.229012
nanocomposite	0.46729	0.392157	0.258065	0.269663	0.321285	0.362319	0.34513
metallic	0.046729	0.05098	0.032258	0.011236	0.016064	0.023551	0.030136
ceramic	0.058411	0.066667	0.129032	0.044944	0.02008	0.025362	0.057416
polymeric	0.077103	0.098039	0.16129	0.179775	0.080321	0.04529	0.10697
semiconductor	0.116822	0.196078	0.258065	0.314607	0.321285	0.181159	0.231336

Table 13- the weight matrix of any groups (choices) in relation with the criteria

criteria	selectivity	Active sur.	effectiveness	stability	behavior	resistance	measuring easiness	production easiness	pollution	economical profit
composite	0.092541	0.135914	0.135732	0.128917	0.197946	0.18225	0.231419	0.136302	0.183926	0.229012
nanocomposite	0.394596	0.372882	0.366499	0.429884	0.358988	0.46612	0.384994	0.387104	0.394691	0.34513
metallic	0.055524	0.042296	0.03273	0.033233	0.03189	0.029003	0.028606	0.0325	0.029982	0.030136
ceramic	0.05796	0.060484	0.053321	0.058279	0.042176	0.054349	0.061844	0.056401	0.056555	0.057416
polymeric	0.132961	0.11773	0.118447	0.109843	0.097038	0.085401	0.103358	0.10598	0.110611	0.10697
semiconductor	0.266418	0.270694	0.293005	0.239844	0.271963	0.182877	0.189779	0.281713	0.224235	0.231336

Table 14- the groups (choices) calculated weight for applying in industry

group	composite	nanocomposite	metallic	ceramic	polymeric	semiconductor
Weight of group	0.174947	0.41123	0.031914	0.056145	0.102767	0.222981

4. CONCLUSIONS

By using the AHP method and mathematical modeling based upon the needed and known criteria, the following results were obtained:

1- the needed criteria from the view of expert (maker decision) are in the following importance level: corrosion resistance, economical profit, environmental pollution, stability, effectiveness, measurement easiness, selectivity, production easiness, the behavior in the medium and active surface.

2- These 6 groups from the view of applying them in industries have this importance ranking: nanocomposite, nanosemiconductor, composite, nanopolymeric, nanoceramic and nanometallic.

3- These results are obtained from the view of an expert group.

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