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Multi criteria decision making to select the suitable method for the preparation of nanoparticles using an analytical hierarchy process

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Selecting the right method for the preparation of nanoparticles is a crucial decision. A wrong decision can result in the product having to be formulated and developed again. One tool that can be useful in determining the most appropriate method is the Analytical Hierarchy Process (AHP). AHP has been employed in almost all areas related to decision-making problems. In this paper, the results of a case study illustrate that the AHP concept can assist designers in the effective evaluation of various methods available for the preparation of nanoparticles. This paper presents the methodology of selecting the most suitable method for preparing nanoparticles using the analytical hierarchy process.

1. Introduction

Novel drug delivery systems (NDDS) are among the areas at the cutting edge of research in the pharmaceutical field today. Pharmaceutical formulations with NDDS have been introduced with the aim of optimizing bioavailability by modulating the time course of the drug concentration in blood (Abu-Izza et al. 1996a, b). All sustained and controlled release products have the common goal of improving drug therapy over that achieved with their non-sustained and non-controlled release counterparts.(Jain You et al. 2006; Babazadeh 2006). The absorption rate of a drug can be decreased by reducing its rate of release from the dosage form. The product so formulated is designed as a sustained action, sustained release, prolonged action, depot, retarded release, delayed action or timed release medication (Banker and Rhodes 2002). This recent interest has been due to various factors, viz: the prohibitive cost of developing new drug entities, expiry of international patents, discovery of new polymeric materials suitable for prolonging drug release, and improvements in therapeutic efficacy and safety achieved by these delivery systems (Gohel and Amin 1998; Jain et al. 2006). Various approaches are available for achieving NDDS such as targeted delivery systems, nanoparticles, prodrugs, transdermal systems, ocular systems, intravaginal and intrauterine systems, injections and implants, microencapsulation, matrix devices, and reservoir devices. One of the most effective approaches comprised nanoparticles.

One of the useful tools in method selection is the Analytical Hierarchy Process (AHP) which was developed at the Wharton School of Business by Saaty (Saaty 1980). This is a powerful and flexible weighted scoring decision making process to help people set priorities and make the best decision. AHP has been widely used to solve problems of multi-criteria decision making in both academic research and in industrial practice. AHP has been implemented in almost all applications related to decision-making and is currently predominantly used in the theme of selection and evaluation especially in the area of engineering, pharmaceuticals, and personal and social areas (Vaidya and Kumar 2006). Generally, implementing AHP is based on the experience and knowledge of the experts or users to determine the factors affecting the decision process (Ho 2008; Dweiri and Al-Oqla 2006). According to Hajeeh and Al-Othman (2005), AHP is an intuitive method for formulating and analyzing decisions whereas Cheng and Li (2001) describe the AHP approach as a subjective methodology. AHP is not only used as a standalone tool but also can be integrated with other techniques. AHP can be combined with techniques such as quality function deployment (QFD), and data envelopment analysis (DEA), and thus integrated it can be applied to a wide variety of fields especially in the logistic and manufacturing areas (Ho 2008). In order to achieve efficiency in selecting the optimum method, appropriate evaluation and decision tools need to be considered. Since AHP applications are related to evaluating and selecting different alternatives or options, it can also be implemented in the product development process, especially to select the most appropriate method. At this stage, designers have to consider a number of factors in order to determine and select the optimum decision options, because an inappropriate decision can lead to the eventual product having to be formulated and developed again. The advantages of using AHP include achieving higher product quality and shortening the product development process. AHP helps to capture both subjective and objective evaluation measures, providing a useful mechanism for checking the consistency of the evaluation measures and alternatives suggested by the team, and thus reducing bias in decision-making. AHP allows organizations to avoid common pitfalls of decision-making processes, such as lack of focus, planning, participation or ownership, which ultimately are costly distractions that can prevent teams from making the right choice (Anonymous 2007). Some applications of AHP in the pharmaceutical field are in selecting alternatives, such as for tablet formulation machines,

Table 1: Scale for pair-wise comparisons Saaty TL (1980)

Relative intensity	Definition	Explanation
1	Equal value	Two requirements are of equal value
3	Slightly more value	Experience slightly favors one requirement over another
5	Essential or strong value	Experience strongly favors one requirement over another
7	Very strong value	A requirement is strongly favored and its dominance is demonstrated in practice
9	Extreme value	The evidence favoring one over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between two adjacent judgements	When compromise is needed
Reciprocals	Reciprocals for inverse comparison	

characterization techniques such as PK studies, release behavior, drug content, microbial versus instrumental assays for determining the potency of antibodies, blenders for mixing powders, liquids or semisolids, site selection for pharmaceutical plants, and very many more. This paper discusses AHP implementation in the area of the method selection process. Here, using AHP can make the job of selecting a method shorter, reduce cost and produce higher product quality. Thus, the paper illustrates the use of AHP in evaluating and determining the most suitable method for nanoparticle preparation from the methods available.

2. Investigations, results and discussion

2.1. Analytical hierarchy process principles

Generally, AHP consists of three main principles, including hierarchy framework, priority analysis and consistency verification (Saaty 1980; Adhikari et al. 2006; Cheng et al. 2007). Formulating the decision problem in the form of a hierarchy framework is the first step of AHP, with the top level representing the overall objectives or goal, the middle levels representing criteria and sub-criteria, and the decision alternatives being at the lowest level. Once a hierarchy framework has been constructed, users are requested to set up a pairwise comparison matrix at each hierarchy and compare options by using a scale pairwise comparison as shown in Table 1. Finally, in the priority stage synthesis, each comparison matrix is solved by an eigenvector method to determine the importance of the criteria and the performance of alternatives (Cheng et al. 2007). These principles can be elaborated by structuring them in a more encompassing nine step process as shown in Fig. 1.

2.2. AHP at the conceptual design stage – case study

Generally, there are six stages in the product development process. One of them is conceptual design. It consists of three processes, namely concept generation, concept evaluation and concept development. Be this as it may, concept evaluation or selection is discussed in this paper. In order to choose the most suitable method for the preparation of nanoparticles, the following AHP steps, as listed in Fig. 1, should be considered:

Table 2: Pairwise comparison of criteria with respect to overall goal

Goal	PI	OS	FE	SU	TI
Process Information (PI)	1	3	A = 5	3	5
Operation Skill (OS)	1/3	1	3	1	3
Feasibility (FE)	1/5	1/3	1	1/3	3
Supplier (SU)	1/3	1	3	1	3
Technical Information (TI)	1/5	1/3	1/3	1/3	1
Total Column	2.067	5.667	10.333	6.333	15.0

Table 3: Synthesized matrix for criteria

Goal	PI	OS	FE	SU	TI	Total row	Priority vector
PI	0.484	0.529	0.405	0.529	0.333	2.281	0.456
OS	0.161	0.176	0.243	0.176	0.200	0.957	0.191
FE	0.097	0.059	0.081	0.059	0.200	0.496	0.099
SU	0.161	0.176	0.243	0.176	0.200	0.957	0.191
TI	0.097	0.059	0.027	0.059	0.067	0.308	0.062
							1.0000

2.2.1. Step 1: Define the problem

A case study for this research is about selecting the best method for the preparation of nanoparticles. After performing several steps of method selection, there are seven possible methods remain, as listed below. Thus, it is necessary to choose the most suitable of these methods by using AHP: M1 Polymer precipitation, M2 Interfacial polymer deposition, M3 Complex coacervation, M4 Cross linking, M5 Emulsion solvent diffusion, M6 Homogenization, M7 Polymerization technique.

2.2.2. Step 2: Develop a hierarchy model

In this section, a hierarchy model for method selection using AHP is introduced. A four-level hierarchy decision process, as shown in Fig. 2, is described below:

Table 4: Calculation to obtain new vector

	1		3		5
	1/3		1		3
0.456	1/5		1/3		1
	1/3		1		3
	1/5	+ 0.191	1/3	+ 0.099	1/3
					New Vector
+ 0.191	3		5		2.409
	1		3		1.017
	1/3	+ 0.062	3	=	0.503
	1		3		1.017
	1/3		1		0.314

Table 5: Random index of analytic hierarchy process

Size of matrix (n)	1	2	3	4	5	6	7	8	9	10	11	12
Random index (RI)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.58

2.2.2.1. Level I. First, the objective, or the overall goal of the decision, is presented at the top level of the hierarchy. Specifically, the overall goal of this application is to 'select the most suitable method for the preparation of nanoparticles'.

2.2.2.2. Level II. The second level represents the main criteria that help to reach the goal i.e., selecting the most suitable method for the preparation of nanoparticles. The main criteria can be classified into five aspects:
Process Information (PI), Operational Skill (OS), Feasibility (FE), Supplier (SU) and Technical Information (TI).

2.2.2.3. Level III. The sub-criteria are represented at the third level of the hierarchy. There are five sub-criteria that refer to pro-

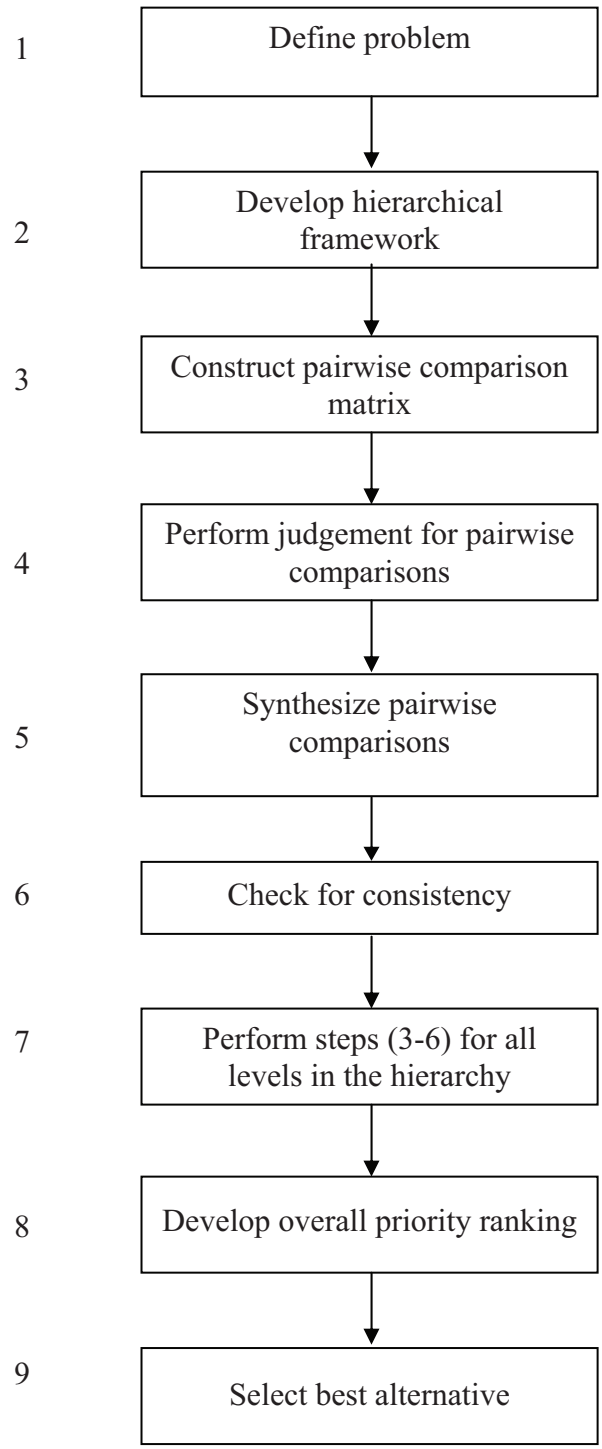

Fig. 1: Steps of the analytical hierarchy process (AHP)

Table 6: Consistency test for criteria

Goal	PI	OS	FE	SU	TI	Priority vector (PV)	New vector (NV)	NV/PV
PI	1	3	5	3	5	0.456	2.409	5.279
OS	1/3	1	3	1	3	0.191	1.017	5.312
FE	1/5	1/3	1	1/3	3	0.099	0.503	5.075
SU	1/3	1	3	1	3	0.191	1.017	5.312
TI	1/5	1/3	1/3	1/3	1	0.062	0.314	5.089
							Total	26.067
							Maximum eigenvalue	35.21

Consistency index CI = 0.053 Consistency ratio CR = CI/RI = 0.05

Table 7: Consistency test for sub-criteria

G/PI	TD	PC	GR	CO	TR	Priority vector (PV)	New vector (NV)	NV/PV
TD	1	3	5	3	3	0.415	2.283	5.501
PC	0.333	1	3	3	3	0.251	1.392	5.551
GR	0.200	0.333	1	0.333	0.200	0.056	0.295	5.259
CO	0.333	0.333	3	1	1	0.127	0.669	5.251
TR	0.333	0.333	5	1	1	0.151	0.781	5.176
							Total	26.739
							Maximum eigenvalue	5.348

Consistency index (CI) = 0.087 Consistency ratio (CR) = 0.08
Note: As the value of CR is less than 0.1, the judgements are acceptable because CR< 0.1 and Table 11 represent the consistency test for the sub-criteria and alternatives. As the value of CR is less than 0.1 for all sub-criteria and alternatives, the judgements are acceptable.

Table 8: Consistency test for sub-criteria

G/OS	TE	KN	Priority vector (PV)	New vector (NV)	NV/PV
TE	1	3	0.750	1.500	2.000
KN	0.333	1	0.250	0.500	2.000
				Total	4.000
				Maximum eigenvalue	2.000

Consistency index (CI) = 0.000 Consistency ratio (CR) = 0.000 Note: As the value of CR is less than 0.1, the judgements are acceptable because CR< 0.1

Table 9: Consistency test for sub-criteria

G/FE	VE	CO	Priority vector (PV)	New vector (NV)	NV/PV
VE	1	3	0.750	1.500	2.000
CO	0.333	1	0.250	0.500	2.000
				Total	4.000
				Maximum eigenvalue	2.000

Consistency index (CI) = 0.000 Consistency ratio (CR) = 0.000 Note: As the value of CR is less than 0.1, the judgements are acceptable because CR< 0.1

Table 10: Consistency test for sub-criteria

G/TI	LT	MN	Priority vector (PV)	New vector (NV)	NV/PV
LT	1	3	0.750	1.500	2.000
MN	0.333	1	0.250	0.500	2.000
				Total	4.000
			Maximum eigenvalue		2.000

Consistency index (CI) = 0.000 Consistency ratio (CR) = 0.000 Note: As the value of CR is less than 0.1, the judgements are acceptable because CR< 0.1

cess information: Type of drugs used (TD) Processing conditions (PI), Growth in the field (GR) Cost (CO) and Hands-on training (TR). Techniques of the method (TE) and the Knowledge about it (KN) add value for Operational Skill. Versatility (VE) and Complexity (CO), and Literature (LT) and Manuals (MN) are the subcriteria that add values to Feasibility and Technical Information respectively.

2.2.2.4. Level IV. Finally, at the lowest level of the hierarchy, the alternative methods (M) for nanoparticle preparation are identified, which are the decision options:
M1 Polymer precipitation, M2 Interfacial polymer deposition, M3 Complex coacervation, M4 Cross-linking, M5 Emulsion solvent diffusion, M6 Homogenization, M7 Polymerization technique.

2.2.3. Step 3: Construct a pairwise comparison matrix

One of the major strengths of AHP is the use of pairwise comparisons to derive accurate ratio scale priorities. Pairwise comparisons are fundamental to the AHP methodology. Thus, a pairwise comparison matrix (size n × n) is constructed for the lower levels with one matrix in the level immediately above. The pairwise comparisons generate a matrix of relative rankings for each level of the hierarchy. The number of matrices depends on the number of elements at each level. The order of the matrix at each level depends on the number of elements at the lower level that it links to.

2.2.4. Step 4: Perform judgement for pairwise comparison

Pairwise comparison begins with comparing the relative importance of two selected items. There are n × (n−1) judgments required to develop the set of matrices in step 3. The decision makers have to compare or judge each element by using the relative scale pairwise comparison as shown in Table 1. The judgements are decided on the basis of the decision makers' or users' experience and knowledge. The scale used for comparisons in AHP enables the decision maker to incorporate experience and knowledge intuitively. For example, when making pairwise comparisons as shown in Table 2, if Process Information (PI) is strongly more important or essential than Feasibility (FE), then a = 5. Reciprocals are automatically assigned to each pairwise comparison.

2.2.5. Synthesizing the pairwise comparison

To calculate the vectors of priorities, the average of normalized column (ANC) method is used (18). In ANC the elements of each column are divided by the sum of the column and then the elements in each resulting row are added and this sum is divided by the number of elements in the row (n). This is a process of averaging over the normalized columns. The summary results for this calculation are shown in Table 3. In mathematical form, the vector of priorities can be calculated as

$$w_i = \frac{1}{n}\sum_{j=1}^{n}\frac{aij}{\sum_i^n a_{ij}}, i, j = 1, 2, \cdots n \quad (1)$$

For instance, the calculation for the first priority vector is as follows
Firstly, $\sum_i^n a_{ij}$ hence, 1 + 1/3 + 1/5 + 1/3 + 1/5 = 2.067.
Secondly $\frac{a_{ij}}{\sum_j^n a_{ij}}$ hence, 1/2.067 = 0.484.
Thirdly, $\sum_{j=1}^{n}\frac{aij}{\sum_i^n a_{ij}}$ hence, 0.484 + 0.529 + 0.405 + 0.529 + 0.333 = 2.281 and finally, divide this sum by the number of elements (n = 5) hence, 2.281/5 = 0.456.

2.2.6. Step 6: Perform consistency verification

Since the comparisons are carried out through personal or subjective judgments, some degree of inconsistency may occur. To ensure the judgments are consistent, a final operation called consistency verification, which is regarded as one of the most advantageous features of the AHP, is incorporated in order to measure the degree of consistency among the pairwise comparisons by computing the consistency ratio (10). The consistency is determined by the consistency ratio (CR). Consistency ratio (CR) is the ratio of consistency index (CI) to random index (RI) for the same order matrices. To calculate the consistency ratio (CR), there are three steps to be implemented as follows:

2.2.6.1. First calculate the Eigenvalue (λ_{max}). To calculate the eigenvalue (λmax), multiply the right of judgement matrix by the priority vector or eigenvector, obtaining a new vector. The calculation to give a new vector is shown in Table 4.
For instance, the calculation for the first row in the matrix is 0.456(1) + 0.191(3) + 0.099(5) + 0.191(3) + 0.062(5) = 2.409
Then, dividing all the elements of the weighted sum matrices or new vector by their respective priority vector element, hence 2.409/0.456 = 5.279; 1.017/0.191 = 5.312; 0.503/0.099 = 5.075; 1.017/0.191 = 5.312; 0.314/0.062 = 5.089
Then calculate the average of these values to obtain λmax = (5.279 + 5.312 + 5.075 + 5.312 + 5.089)/5 = 5.213

2.2.6.2. Second: Calculate the consistency index (CI).

$$CI = (\lambda\,\max - n)/(n - 1) \quad (2)$$

Where n is the matrix size.
CI = (5.213−5)/(5−1) = 0.053

2.2.6.3. Finally calculate consistency ratio (CR). The CR can be calculated using the formula

$$CR = CI/RI \quad (3)$$

Selecting the appropriate value of random index (RI), for the matrix size of five using Table 5, RI = 1.12. Then calculate the consistency ratio (CR), CR = CI/RI = 0.053/1.12 = 0.05. As the value of CR is less than 0.1, the judgements are acceptable. If CR > 0.1, the judgement matrix is inconsistent. To obtain a consistent matrix, judgements should be reviewed and improved. The summary results for this calculation are shown in Table 6

2.2.7. Step 7: Steps 3–6 are performed for all levels in the hierarchy model

The elements in Tables 7–10.

Table 11: Consistency test for alternatives

	Priority vector/eigenvector											
	Goal											
			PI				OS			FE	SU	TI	
	TD	PC	GR	CO	TR	TE	KN	VE	CO		LT	MN
M1	0.175	0.215	0.093	0.170	0.112	0.144	0.189	0.126	0.124	0.120	0.262	0.195
M2	0.104	0.081	0.074	0.290	0.061	0.055	0.058	0.229	0.227	0.066	0.191	0.316
M3	0.140	0.145	0.066	0.140	0.118	0.092	0.174	0.126	0.124	0.120	0.144	0.125
M4	0.126	0.044	0.070	0.127	0.061	0.062	0.055	0.229	0.227	0.050	0.093	0.101
M5	0.323	0.201	0.420	0.050	0.311	0.269	0.174	0.051	0.047	0.322	0.045	0.034
M6	0.080	0.162	0.074	0.167	0.084	0.147	0.174	0.169	0.182	0.100	0.198	0.165
M7	0.051	0.152	0.204	0.056	0.253	0.230	0.174	0.072	0.070	0.223	0.068	0.065
Consistency test												
λmax	7.5000	7.638	7.172	7.315	7.307	7.617	7.027	7.436	7.437	7.388	7.654	7.490
CI	0.083	0.106	0.029	0.052	0.051	0.103	0.005	0.073	0.073	0.065	0.109	0.082
RI	1.320											
CR	0.063	0.081	0.022	0.040	0.039	0.078	0.003	0.055	0.055	0.049	0.083	0.062

2.2.8. Develop overall priority ranking

After the consistency calculation for all levels has been completed, further calculation of the overall priority vector to select the best preparation method must be performed. The elements/points in Table 12 represent priority vectors for criteria, sub-criteria and alternatives.

The elements in Table 13 represent the overall priority vector for seven alternative methods with respect to the sub-criteria. The overall priority vector can be obtained by multiplying the priority vector for the alternative methods by the vector of priority of the sub-criteria. An example of the overall priority calculation is as follows:

$0.175(0.415) + 0.215(0.251) + 0.093(0.056) + 0.170(0.127) + 0.112(0.151) = 0.170$

The elements in Table 14 show the overall priority vector of the alternatives with respect to the criteria. The overall priority vector can be obtained by multiplying the priority vector for the Method alternatives by the priority vector of the criteria. An example of the overall priority calculation is as follows:

$0.170\,(0.456) + 0.156(0.191) + 0.125(0.099) + 0.120(0.191) + 0.245(0.062) = 0.158$

2.2.9. Selection of most suitable method

Table 15 shows that the emulsion solvent diffusion technique (M-5) has the highest value (0.236 or 23.6%) of the alternative methods that are applicable to the preparation of the nanoparticles. The second highest is (M-1) with a value of 0.158 (15.8%), and the lowest value or last choice is method 4 (M-4) with a value

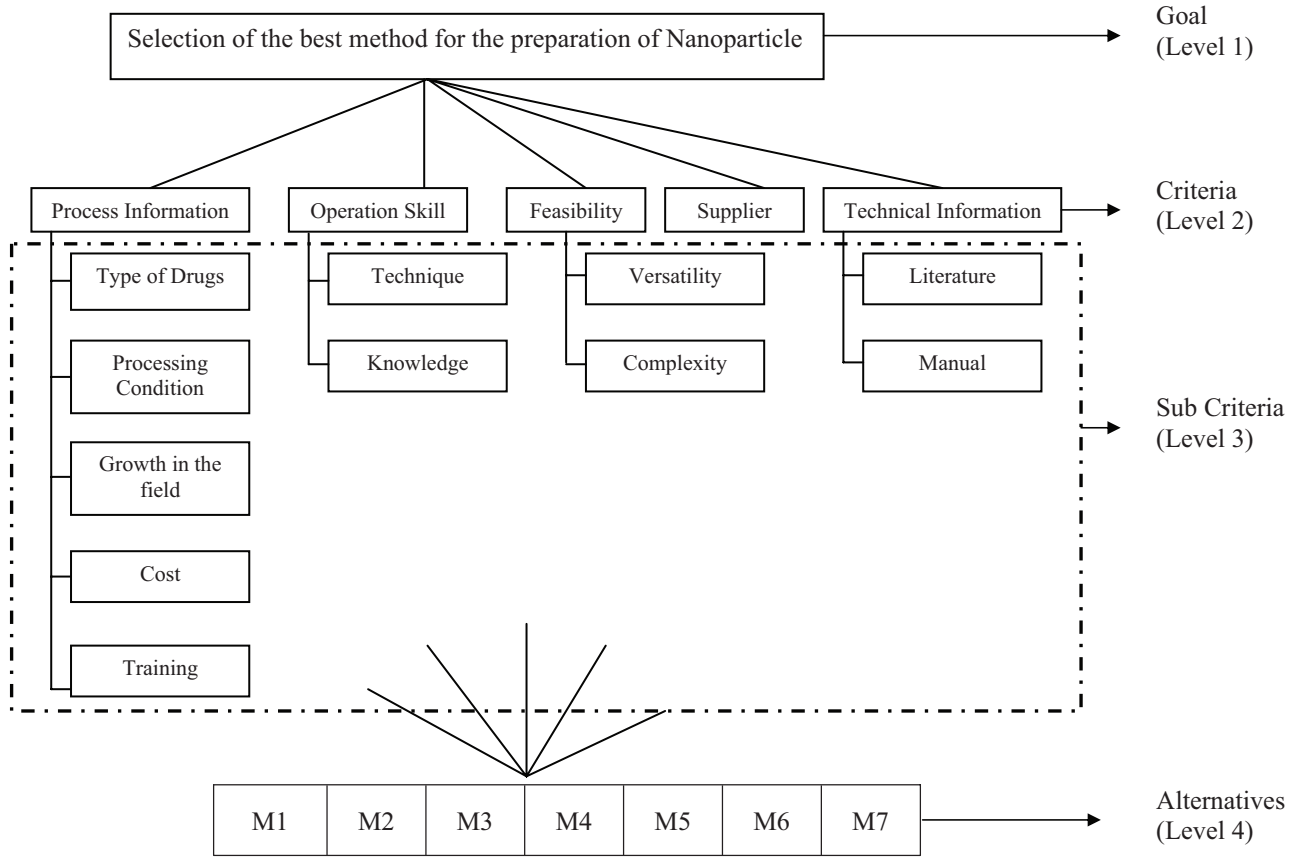

Fig. 2: Hierarchy model for selection of method for preparation of nanoparticles

Table 12: All priority vectors for criteria, sub-criteria and alternatives

						Priority vector						
						Goal						
Criteria			PI			OS		FE		SU	TI	
			0.456			0.191		0.099		0.191	0.062	
Sub-criteria	TD	PC	GR	CO	TR	TE	KN	VE	CO		LT	MN
	0.415	0.251	0.056	0.127	0.151	0.750	0.250	0.750	0.250		0.750	0.250
Alternatives												
M1	0.175	0.215	0.093	0.170	0.112	0.144	0.189	0.126	0.124	0.120	0.262	0.195
M2	0.104	0.081	0.074	0.290	0.061	0.055	0.058	0.229	0.227	0.066	0.191	0.316
M3	0.140	0.145	0.066	0.140	0.118	0.092	0.174	0.126	0.124	0.120	0.144	0.125
M4	0.126	0.044	0.070	0.127	0.061	0.062	0.055	0.229	0.227	0.050	0.093	0.101
M5	0.323	0.201	0.420	0.050	0.311	0.269	0.174	0.051	0.047	0.322	0.045	0.034
M6	0.080	0.162	0.074	0.167	0.084	0.147	0.174	0.169	0.182	0.100	0.198	0.165
M7	0.051	0.152	0.204	0.056	0.253	0.230	0.174	0.072	0.070	0.223	0.068	0.065

Table 13: Overall priority vectors for sub-criteria with respect to criteria

	Overall priority vector				
M1	0.170	0.156	0.125	0.120	0.245
M2	0.114	0.056	0.228	0.066	0.222
M3	0.134	0.112	0.125	0.120	0.139
M4	0.093	0.060	0.228	0.050	0.095
M5	0.262	0.246	0.050	0.322	0.042
M6	0.112	0.154	0.173	0.100	0.190
M7	0.116	0.216	0.071	0.223	0.067

of only 0.092 (9.2%). M-5 is the preferred choice since it has the highest value among the seven alternatives.

In the case study, the AHP technique was applied to selecting amongst alternative preparation methods for nanoparticles and thereby opting for the best technique. The composite score is used for the final ranking of the alternatives. The solution of the problem involves finding the composite score that reflects the relative priorities of all the alternatives at the lowest level of the hierarchy. The composite score favored the selection of the emulsion solvent diffusion technique (score = 0.236, Table 14, 15) over the other alternative methods.

In the present study, a hierarchy was designed containing the decision as goal, the alternatives for reaching it and the criteria for evaluating the alternatives and subcriteria for evaluating the criteria. A priority was determined for each node based on its strength, relative to the other nodes. The priorities of the criteria would indicate their relative importance in reaching the goal.

Table 14: Overall priority vector for alternatives with respect to criteria

	Priority Vector					
	PI	OS	FE	SU	TI	Overall Priority
	0.456	0.191	0.099	0.191	0.062	
M1	0.170	0.156	0.125	0.120	0.245	0.158
M2	0.114	0.056	0.228	0.066	0.222	0.111
M3	0.134	0.112	0.125	0.120	0.139	0.126
M4	0.093	0.060	0.228	0.050	0.095	0.092
M5	0.262	0.246	0.050	0.322	0.042	0.236
M6	0.112	0.154	0.173	0.100	0.190	0.129
M7	0.116	0.216	0.071	0.223	0.067	0.148

The priorities of the alternatives would indicate their relative strengths as the best method.

The alternative with the highest priority would be the most suitable method and the ratios of the method priorities would indicate their relative strength (Saaty 1980). Obviously, the priority of the goal (to select the most suitable method) would be 1.000.

The priorities of the criteria Process Information (PI) Operation Skill (OS), Feasibility (FE), Supplier (SU), and Technical Information (TI), are 0.456, 0.191, 0.099, 0.191 and 0.062 respectively (Table 12):

The priorities of the subcriteria Type of Drugs used (TD), Processing Conditions to be carried out throughout the experiment (PC), Growth of the technique in the field (GR), Overall cost (CO), Hands-on training designed for the technique (TR), Knowledge (KN), Versatility (VE), Complexity (CO), Literature (LT) and Manuals (MN) are 0.415, 0.251, 0.056, 0.127, 0.151, 0.750, 0.250, 0.750, 0.250, 0.750 and 0.250 (Table 12).

The overall priorities of the subcriteria with respect to the criteria for each method are given in Table 13.

The overall priorities for the alternatives with respect to the criteria are given in Table 14. Method M5 emulsion solvent diffusion technique scored 0.236, M1 polymer precipitation scored 0.158, M7 polymerization technique scored 0.148, M6 homogenization techniques scored 0.129, M3 complex coacervation scored 0.126, M2 interfacial polymer deposition scored 0.111 and finally M4 crosslinking technique scored 0.029.

The alternative with the highest priority would achieve the goal as per Saaty.

The alternative in this case, M5 emulsion solvent diffusion technique, scoring 0.236 was the one with highest priority among all the other alternatives.

Hence, having worked out the AHP technique, the emulsion solvent diffusion technique is judged to be the most suitable method for the preparation of nanoparticles.

Table 15: Result of selection

No	Best selection	
1	M5	0.236
2	M1	0.158
3	M7	0.148
4	M6	0.129
5	M3	0.126
6	M2	0.111
7	M4	0.029

In conclusion, this paper presents the methodology for evaluating and selecting the most appropriate method for preparation of nanoparticles by implementing the analytical hierarchy process (AHP). AHP can be used to help designers to evaluate and select the best method based on the criteria and sub-criteria aspects of a decision. The analysis reveals that Method 5, the emulsion solvent diffusion technique, is the most appropriate for the preparation of nanoparticles because it has the highest value (0.236 or 23.6%) of any of the methods. The application of the AHP for selecting the most suitable method for the preparation of nanoparticles can improve the quality of the product and shorten the product development process.

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