International Journal of PharmTech Research
CODEN (USA): IJPRIF ISSN : 0974-4304
Vol.6, No.4, pp 1362-1367, Aug-Sept 2014

Application of the Analytic Hierarchy Process in the selection of Coating Materials for the Preparation of an Innovative Capsule Form for the Colon Specific Delivery

P. Kathiravan*, V.P. Pandey,

Department of Pharmacy, Faculty of Engineering and Technology, Annamalai University, Annamalai nagar 608 002, India.

***Corres.author: kathirpceutics@gmail.com**
Mobile: +919003654628

Abstract: The use of qualitative judgements in multicriteria decision models is receiving increasing attention and a variety of approaches have been developed which cover a wide range of techniques. One method which has received increasing attention in the literature is the relatively recently developed analytic hierarchy process (‘AHP). This method has been widely documented in a variety of problem areas. With the exception of a few cases, this qualitative decision-making technique has not been used extensively in selection of coating materials in the preparation of novel capsule. This study briefly reviews the AHP and suggests potential applications in the selection of coating materials in the preparation of novel capsule.
Keywords: Analytical Hierarchy Process, novel capsules, coating materials, Eudragit, Hydroxy propylmethyl cellulose and Carboxy methylethyl cellulose.

Introduction

Selection of coating materials in the preparation of novel capsule are usually complex; many factors may be of importance: price policy, reliability, physio chemical characteristics, risk perception, transportation, storage facilities, working experiences, etc. These problems are faced on various levels: research, academics, industry, etc. Decision makers who rely on traditional operations research models risk ignoring important qualitative factors in their decisions, whereas decision makers who attempt to take into account these qualitative factors must risk using unscientific or adhoc methods.

Another factor which limits the use of prompt coating materials decision problems in the preparation of novel capsule is the problem of data availability and data precision. Many novel capsule formulations lack the means of maintaining high quality coating material statistics collection. Consequently official statistics suffer from a lack of precision and reliability. One major contribution of the analytic hierarchy process (AHP) is its focus on overcoming these drawbacks. The AHP models presented in this study are qualitative techniques which rely on the judgement and experience of decision makers to prioritize information for better decisions.

The AHP Process

The AHP developed by Thomas Saaty[1] is a multicriteria decision-making technique which decomposes a complex problem into a hierarchy, in which each level is composed of specific elements. Generally, implementing AHP is based on the experience and knowledge of the experts or users to determine the factors affecting the decision process[2,3]. According to Hajeeh and Al-Othman, AHP is an intuitive method for formulating and analyzing decisions[4] whereas Cheng and Li describe the AHP approach is a subjective methodology[5]. The overall objective of the decision lies at the top of the hierarchy, and the criteria, sub-criteria and decision alternatives are on descending levels of this hierarchy. The hierarchy does not need to be complete, i.e. an element in a given level does not have to function as a criterion for all the elements in the level below. A hierarchy can thus be divided into sub-hierarchies sharing only a common top most element.

Once the hierarchical model has been structured for the problem, the participating decision makers provide pairwise comparisons for each level of the hierarchy, in order to obtain the weight factor of each element on that level with respect to one element in the next higher level. This weight factor provides a measure of the relative importance of this element for the decision maker.[6-8]

To compute the weight factors of n elements, the input consists of comparing each pair of the elements using the following scale set:

S = {1/9, 1/8, 1/7, 1/6, 1/5, 1/4, 1/3, 1/2, 1, 2, 3, 4, 5, 6, 7, 8, 9}

The pairwise comparison of element i with element j is placed in the position of a_{ij} of the pairwise comparison matrix A as shown below:

$$A = \begin{bmatrix} a_{11} & a_{12} & . & . & .a_{1n} \\ a_{21} & a_{22} & . & . & .a_{2n} \\ . & & & & . \\ . & & & & . \\ . & & & & . \\ a_{n1} & a_{n2} & . & . & .a_{nn} \end{bmatrix}$$

The reciprocal value of this comparison is placed in the position a_{ji} of A in order to preserve consistency of judgement. Given n elements, the participating decision maker thus compares the relative importance of one element with respect to a second element, using the 9-point scale shown in Table 1. For example, if element one was strongly favoured over element two, then a_{l2} would be given a score of 5. If the converse was true, element two was strongly favoured over element one, then a_{l2} would be given the reciprocal score of l/5. The pairwise comparison matrix is called a reciprocal matrix for obvious reasons.

Table 1: The 9 point scale for pairwise comparisons[6]

S.No	Definition	Explanation
1	Equal importance	Two elements contribute identically to the objective
3	Weak dominance	Experience or judgement slightly favours one element over another
5	Strong dominance	Experience or judgement strongly favours one element over another
7	Demonstrated dominance	An element's dominance is demonstrated in practice
9	Absolute dominance	The evidence favouring an element over another is affirmed to the highest possible order
2,4,6,8	Intermediate values	Further subdivision or compromise is needed

Advantages of using AHP

The advantages of using the AHP is as follows[9]

1. It formalizes and renders systematic what is largely a subjective decision process and as a result facilitates "accurate" judgements;

2. As a by-product of the method, decision makers receive information about the implicit weights that are placed on the evaluation criteria; and

3. The use of computers makes it possible to conduct sensitivity analysis on the results.

Another advantage of using AHP is that it results in better communication, leading to a clearer understanding and consensus among members of decision-making groups so that they are likely to become more committed to the alternatives selected[10]

AHP also has the ability to identify and take into consideration the decision maker's personal inconsistencies. Decision makers are rarely consistent in their judgements with respect to qualitative aspects. The AHP method incorporates such inconsistencies into the model and pro-vides the decision maker with a measure of these inconsistencies.

A consistency ratio is taken as the ratio of the consistency of the results being tested to the consistency of the same problem evaluated with random numbers. This ratio provides the user with a value that can be used to judge the relative quality of the results. If a consistency ratio of less than 0.10 is obtained, then the results are sufficiently accurate, and further evaluation is not needed. However, if the consistency ratio is greater than 0.10, the results may be arbitrary and the preferences should be re-evaluated or discarded.

The great advantage of the AHP lies in its ability to handle complex real life problems and with its ease of use. Compared with five different utility models for determining weights and priorities, AHP was found to produce the most credible results of all the models tested[11]

The ability of the AHP to analyse different decision factors without the need for a common numerate, other than the decision makers' assessments, makes it one of the favourable multicriteria decision support tools when dealing with complex socioeconomic problems in developing countries. This is because it enables social, cultural, and other non-economic considerations to be incorporated into the decision-making process.

We illustrate the procedure with the following research study from selecting the best coating material in the preparation of novel capsule.

Materials and methods

The novel capsules are designed in a way to release the drug in the alkaline pH for which certain appropriate polymers to be used. A wrong decision can result in the product to be formulated and developed again. In the preparation of the novel capsules, there arise a bias in selecting the suitable coating materials among (P1) Polyvinyl acetate phthalate, Hydroxy ethyl methyl cellulose and Hydroxypropyl methyl cellulose-Acetate succinate as inner, middle and outer layer respectively (P2) Eudragit, Hydroxy propylmethyl cellulose and Carboxy methylethyl cellulose as inner, middle and outer layer respectively, and (P3) Shellac, Hydroxy propyl cellulose, Cellulose acetate phthalate as inner, middle and outer layer respectively. The criteria considered are (A) Risk of polymer failure (Reliability), (B) physic-chemical nature, (C) Cost and (D) Availability. The first step in AHP is to develop a graphical representation of the problem in terms of the overall goal, criteria and decision alternatives. Figure 1 shows the hierarchy for the best coating material selection problem.

The top level of the hierarchy gives the overall goal: to determine the appropriate coating material for the preparation of the novel capsule. The second level shows the four criteria that contribute to the achievement of the overall goal. The three decision alternatives P1, P2 and P3 are shown at the third level.

To use the AHP, the decision maker must specify his judgements of the relative importance of each criteria's contribution towards achieving the overall goal[12,13]

The evaluation will be elicited using question such as "Given the two criteria cost and reliability, which one is more important in determining the best coating material to be allocated to each alternative? How important?" Similar pairwise comparisons for other criteria can be done to generate the pairwise comparison matrix[14]

The decision maker believes, for example, that reliability is twice as important as production cost. As a result production cost is 1/2 as important as reliability, as indicated above. The rest of the matrix is filled in a similar fashion.

$$\begin{array}{c|cccc} & A & B & C & D \\ \hline A & 1 & \frac{1}{2} & 3 & 4 \\ B & 2 & 1 & 6 & 9 \\ C & \frac{1}{3} & \frac{1}{6} & 1 & 2 \\ D & \frac{1}{4} & \frac{1}{9} & \frac{1}{2} & 1 \end{array}$$

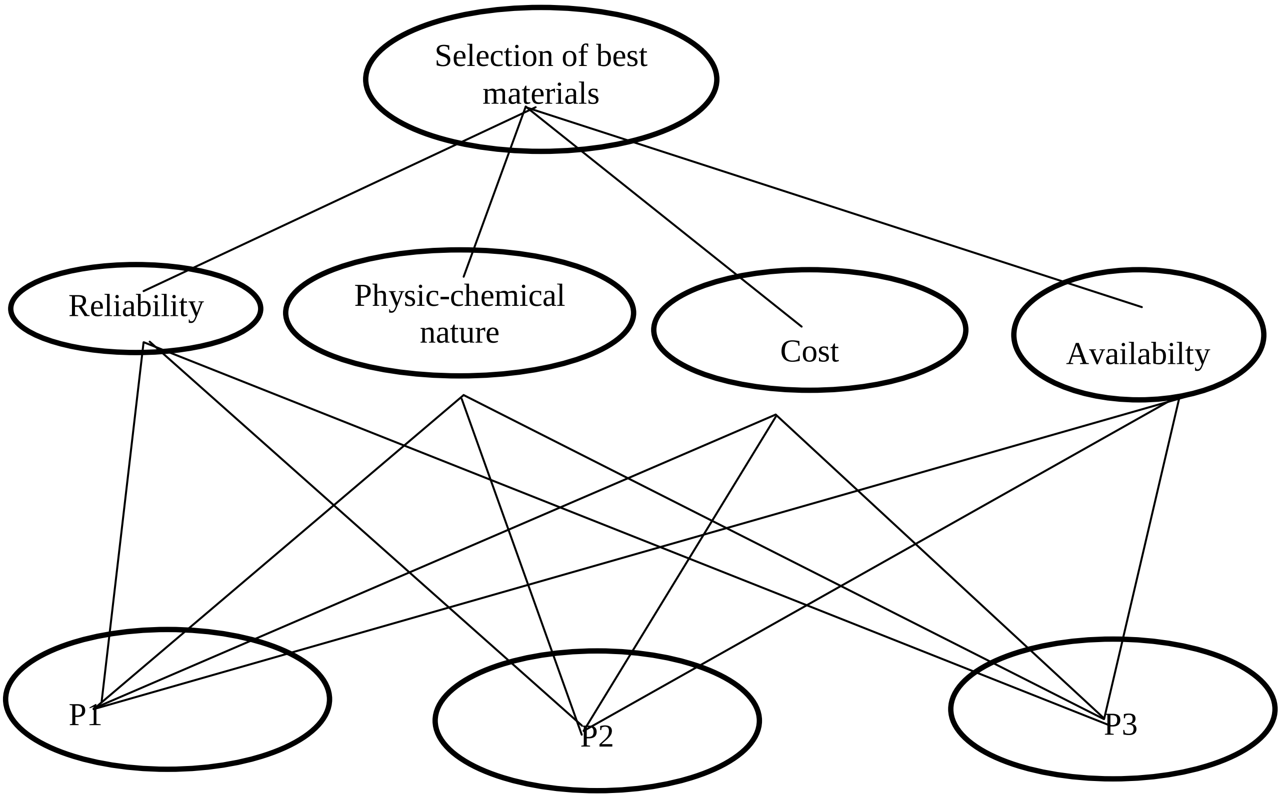

Figure 1: Hierarchy of coating materials selection problem

Results

From this preference matrix a corresponding set of weights (the eigen-vector w) and a consistency ratio (CR) are determined by the AHP computer program known as “Expert Choice”. These are:

$$CR = 0.006 \qquad \mathbf{w} = \begin{bmatrix} 0.274 \\ 0.564 \\ 0.102 \\ 0.060 \end{bmatrix}$$

The consistency ratio is the ratio of the decision maker’s inconsistencies and the inconsistencies obtained from randomly generated preferences.

The next step is to make pairwise comparisons for each coating material alternative with respect to each of the criteria. We illustrate this with respect to reliability of the second attribute.

$$\begin{array}{c|ccc} & P1 & P2 & P3 \\ \hline P1 & 1 & 1/3 & 1/6 \\ P2 & 3 & 1 & 1/3 \\ P3 & 6 & 3 & 1 \end{array}$$

$$CR = 0.016 \qquad w = \begin{bmatrix} 0.096 \\ 0.251 \\ 0.653 \end{bmatrix}$$

Here, the decision maker believes, for example, that P1 is three times as risky as P2. Similar pairwise comparisons must be made with respect to each of the three attributes. The resulting set of weights for each of the alternatives with respect to each criteria are presented in following matrix.

Coating Materials

Attributes		P1	P2	P3
	cost	0.130	0.660	0.210
	B	0.096	0.251	0.653
	C	0.400	0.340	0.260
	D	0.770	0.170	0.060

Finally the portions of the selection decision to be allocated to each coating material are found by determining the product of the criteria priorities and the coating material weights as shown below:

$$\begin{array}{c} P1 \\ P2 \\ P3 \end{array} = 0.274 \overset{A}{\begin{bmatrix} 0.130 \\ 0.660 \\ 0.210 \end{bmatrix}} + 0.564 \overset{B}{\begin{bmatrix} 0.096 \\ 0.251 \\ 0.653 \end{bmatrix}} + 0.102 \overset{C}{\begin{bmatrix} 0.400 \\ 0.340 \\ 0.260 \end{bmatrix}} + 0.060 \overset{D}{\begin{bmatrix} 0.770 \\ 0.170 \\ 0.060 \end{bmatrix}} = \begin{bmatrix} 0.177 \\ 0.458 \\ 0.456 \end{bmatrix}$$

The composite score indicates that according to the realities facing, it has been decided to allocate about 17.7% of the selection decision to P1, 45.8% to P2 and 45.6% to P3.

Thereby as per the scores gained, the polymer (P2) Eudragit, Hydroxy propylmethyl cellulose and Carboxy methylethyl cellulose was chosen to be the most appropriate coating material for the preparation of a novel capsule form which is followed by (P3) Shellac, Hydroxy propyl cellulose, Cellulose acetate phthalate and finally (P1) Polyvinyl acetate phthalate, Hydroxy ethyl methyl cellulose and Hydroxypropyl methyl cellulose-Acetate succinate

The computations presented here are intended to be an “answer” to the coating material selection problem and as well as an illustration of the steps involved when using the AHP.

Conclusions

This study has presented the use of the AHP in the decision area of selecting suitable coating materials in the preparation of novel capsule. Decision hierarchies have been suggested for: (a) determination of the most appropriate coating materials in the novel capsule preparation. The hierarchy presented in this article illustrates the wide range of multi-factor coating material selection decisions in the novel capsule preparation to which AHP can be applied. AHP offers a unique and valuable method for integrating judgements with the available coating materials. This integration will facilitate the application of most appropriate coating materials in the preparation.

Several interesting questions remain to be explored in future research. First, the evaluation of these hierarchical models using field studies is desirable. Second, the extent to which the suggested AHP models would offer a better procedure than ad hoc or other existing approaches is an empirical question that needs field or laboratory testing. What we have attempted to provide here is an introductory framework to serve as a foundation for further refinements and additions.

References

1. Saaty TL, Decision Making for Leaders. RWS Publications, Pittsburgh, USA, 1992, Ho W (2008) Integrated Analytic Hierarchy Process and its applications - a literature review. Eur J Operational Res 186: 211-228.
2. Dweiri F, Al-Oqla FM; Material selection using Analytical Hierarchy Process. Intl J Comput Applic Technol, 2006, 26 (4): 82-189.
3. Hajeeh M, Al-Othman A; Application of the Analytical Hierarchy Process in the selection of desalination plants. Desalination, 2005, 174: 97-108.
4. Cheng EWL, Li H; Information priority-setting for better resource allocation using Analytic Hierarchy Process (AHP). Inform Manage Comput Security, 2001, 9(2): 61-70.
5. Saaty TL, The Analytic Hierarchy Process. New York, McGraw Hill,1980
6. Adhikari I, Kim SY, Lee YD; Selection of Appropriate Schedule Delay Analysis, 2006
7. Cheng SC, Chen MY, Chang HY, and Chou TZ; Semantic-based facial expression recognition using Analytical Hierarchy Process. J Expert Syst Applic, 2007, 33: 86-95.
8. Narasimhan R, An analytical approach to supplier selection. Journal of Purchasing and Materials Management, 1983, 19(l), 227-32.
9. Harker PT, and Vargas LG; The theory of ratio scale estimation: Saa-ty's Analytic Hierarchy Process. Management Science, 1987, 33(1l), 1383-1403.
10. Schoemake PJ, and Waid CC; An experimental comparison of different approaches to determining weights in additive utility models. Management Science, 1982, 28(2), 182-196.
11. Velmurugan R, and Selvamuthukumar S; Multi-criteria decision making to select the suitable method for the preparation of nanoparticles using Analytic Hierarchy Process. Pharmazie, 2011, 66: 836-842.
12. Velmurugan R, and Selvamuthukumar S; The analytic network process for the pharmaceutical sector: Multi criteria decision making to select the suitable method for the preparation of nanoparticles. Daru journal of pharmaceuticals sciences, 2012, 20:59
13. Saaty TL, Axiomatic foundation of the Analytic Hierarchy Process Management Science, 1986, 32(7), 841-855.
14. Forman EH, and Saaty TL; Expert Choice Software Package for IBM PC. Pittsburgh, PA, USA,1991.

*****