Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2013, 5(11):69-72

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Study on design of life circle assessment system for chemical products

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ABSTRACT

As an important role in national economy, chemical industry has polluted the environment because of high energy consumption, behindhand technology, high material loss and so on. Life circle assessment (LCA) is one technology for evaluating the full environmental consequences in the entire life circle from raw materials acquisition, manufacturing to final disposal. As one new method of environmental management and preventive protection, LCA is mainly applied to evaluate the environmental load of a kind of production, working procedure and manufacture activity by the quantitative analysis on the usage of energy and material and the let of offal. LCA was introduced into the chemical industry field in the 1990s. On the basis of studying LCA theories and methods, a LCA system for chemical products (CP-LCA) is established according to the characteristic of chemical products and the properties of resource, environment and personal health. The establishment of evaluation system will improve the work efficiency of valuators.

Keywords: chemical products; life circle assessment; system

INTRODUCTION

Chemical industry is an industry with serious pollution, especially the wastewater from chemical industry containing a lot of materials that can damage the ecological environment and human health. The production process of chemical products not only consumes resources and energies, but also discharges toxic and hazardous matters to the environment. Therefore, it is of great significance to construct the life circle assessment model of chemical product production process and to evaluate the life circle of chemical products.

LIFE CIRCLE ASSESSMENT MODEL

According to the technical framework of the life circle assessment, the first step of the life circle assessment effect of chemical products is to classify and characterize the content on the list. The second step is to standardize data of each environmental effect type, and then weigh the different types of environmental effects, and at last, compare different products, different techniques and different processes. Currently, the most commonly used methods are expert grading method and model calculation method[1-3].

Classification

According to the definition of purpose and range and according to the data collected, the environmental effect assessment types of the chemical product production and life circle can be divided into three categories: resource exhaustion, ecological effect and human health effect. Each of these three categories further contains a lot of subclasses. In this study, the environmental effect can be measured by indexes as global warming potential (GWP), photochemical pollution (POCP), acidification pollution (AP) and human health effect[4-6]. Considering the features of chemical product production environment carrying capacity, six indexes are adopted, and the detailed information is shown in table -1.

Table-1 Environment impact assessment index in chemical products production process

Classification	Relevant Items
Global Warming Potential GWP	CO_2, etc
water Eutrophication NP	NO_x, COD, SS, etc
Photochemical Pollution POCP	Formaldehyde, carbinol, xylene, etc
Potential Groundwater Pollution ECA	heavy metal ion, Ag^+, etc
Acidification Pollution AP	SO_2,NO_x,etc
Human Health Effect HT	Formaldehyde, carbinol, NO_x, etc

Characterization

The method of relative quantitation is often adopted in characterization, in which an object of reference is designated to each environmental effect index. The environmental effects of other environmental pollutants are expressed by the equivalent of the reference object. The calculation of each environmental effect classification refers to the literature references [1] and [2]. The calculation mode of environment carrying capacity equivalent is shown as follows: the environmental pollution carrying capacity equivalent of chemical product is equal to the product of multiplying each environmental pollution quantity by each environmental pollution equivalent quantity[7] .

Standardization

The aim of data standardization is to provide a comparable standard for the relative size of each environmental effect type, and the calculation formula is as follows: relative index of environment carrying capacity is equal to the result of environmental load equivalent being divided by the total equivalents of environmental load. The raw and auxiliary materials and the environmental load of power consumption in this study are gained by multiplying the discharge data of the Chinese public process contaminant by relevant raw material amount and by power consumption amount[8].

Weighting Evaluation

A specific environmental effect number is gained by determining the weighting coefficient of each environmental load. Considering the features of chemical products, Analytical Hierarchy Process is employed (AHP, the Analytical Hierarchy Process). The calculation processes of AHP are explained in the following parts[7-9].

(1) Define the importance scale of environmental effect types

The importance scale of environmental effect types is gained after inquiring relevant literature references and combining the suggestions of experts, which is shown in table -2.

Table-2 Environmental impact category importance scale in Chemical products production process

Types	HT	POCP	NP	GWP
HT	1	3	3	5
POCP	1/3	1	1	3
NP	1/3	1	1	3
GWP	1/5	1/3	1/3	1
AP	1/7	1/5	1/5	1/3
ECA	1/9	1/7	1/7	1/5

A judgment matrix A is got according to the data in the above table.

$$A = \begin{bmatrix} 1 & 3 & 3 & 5 & 7 & 9 \\ 1/3 & 1 & 1 & 3 & 5 & 7 \\ 1/3 & 1 & 1 & 3 & 5 & 7 \\ 1/5 & 1/3 & 1/3 & 1 & 3 & 5 \\ 1/7 & 1/5 & 1/5 & 1/3 & 1 & 3 \\ 1/9 & 1/7 & 1/7 & 1/5 & 1/3 & 1 \end{bmatrix}$$

(2) Calculate the set average value of element in each line of the judgment matrix

$$\varpi_i = 6\sqrt{\prod_{j=1}^{6} a_{ij}} \qquad \text{i,j=1,2,3,4,5,6}$$

(3) Normalization

The formula to calculate normalization is $\varpi_i = \frac{\varpi_i}{\sum_{j=1}^{6} \varpi_j}$, i,j=1,2,3,4,5,6

(4) Calculate the maximum eigenvalue of the judgment matrix

$$\lambda_{max} = \sum_{i=1}^{m} \frac{(A\varpi)}{m\varpi_i}$$

In the formula, $A\varpi_i$ refers to the i element of the vector.

RESULTS AND DISCUSSION

There are some subjective factors when the system element is judged. Therefore, the relative importance among the judged indexes cannot be judged completely and accurately, and as a result there would be deviations in the judgment matrix. Take matrix A as an example, if the matrix A is completely compatible, the formula $\lambda_{max} = n$ is adaptable. If the matrix A is completely incompatible, the formula $\lambda_{max} > n$ is adaptable. $\lambda_{max} - n$ can define the degree of the compatibility. If the compatible index is P, then the calculation[4] of P is as follows:

$$P = \frac{\lambda_{max} - n}{n - 1}$$

In this formula, λ_{max} is the maximum characteristic root of the judgment matrix A. The consistency index is set as K, and the calculation of K is as follows: $K = \frac{P}{Q}$

In the above-mentioned formula, Q is the random index. When P is 0, there is consistency and $\lambda_{max} > n$. If P>0, relevant judgment is based on P<0.1. Saaty holds that if the consistency index Q is less than 0.1, it indicates that the consistency of judgment matrix can be acceptable and the weighting vector W is acceptable, which is shown in table -3.

Table-3 Randomness index value

n	1	2	3	4	5	6	7
Q	0	0	0.58	0.9	1.12	1.24	1.32

Through the above steps, the weighting value of each environmental effect types can be calculated at last, and the calculation result is shown in table- 4.

Table-4 Environmental impact weights

Environmental Influence Type	HT	POCP	NP	GWP	AP	ECA
Weighting Value	0.424	0.013	0.204	0.094	0.048	0.026

According to the weighting value in the above-mentioned table, weight and summate the relative index of the environmental load, and get the total environmental load indexes of the chemical product production.

Acknowledgments
The research is funded by the project of State Key Laboratory of Geohazard Prevention and Geoenvironment Protection(No. SKLGP2012Z010).

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