CHAPTER 27

THE PLASTICS INDUSTRY

CHARACTERISTICS OF THE WASTE WATER

The main raw materials used for the production of plastics are ethene, vinyl chloride, styrene, phenols, formaldehyde, urea, acetylene and benzene.

The production of these monomeric compounds involves waste water problems that have been mentioned in conjunction with the organic chemicals industry. The waste water problems of the polymerization process will be treated in this chapter. The final formation of the polymers does not involve waste water problems which cannot be solved by settling, since the polymers are generally insoluble in water.

The basic production processes for the polymers are condensation and polymerization in the presence of catalysts. Sometimes intermediate stages are necessary.

The plastics industry discharges relatively small amounts of polluted water. The greater portion of the effluent is cooling water, but a small amount of polluted effluent contains certain quantities of intermediate products, by-products and end-products which are present in solution either as suspended solids or as emulsions.

Resin, organic acids, tetrahydric alcohol, pentaerythritol, formaldehyde, sodium formate, phenols, urea and, benzene might be present, depending on the polymers being produced.

The concentration of the impurities varies over a fairly wide range (Dickerson, 1949 and 1950). The BOD value may be anything from 200 to 10000 mg O_2/l. The waste water is generally acidic.

Three types of waste water can be distinguished in the plastics industry:

1. Waste water which contains biodegradable monomeric and polymeric compounds, such as the waste water from the manufacture of polyacrylics.
2. Waste water which, in addition to non-refractory compounds contains nutrients and suspended refractory compounds which are often partially polymerized materials. This type of waste water is produced in the manufacture of polystyrene and poly-ethylene.

3. Waste water which as well as non-refractory compounds contains toxic materials such as cyanide. This type of waste water comes from the manufacture of polyacrylonitrile, acrylo-nitrile-butadienestyrene copolymers and others.

Table 27.1 shows a characteristic analysis of the three types of waste water.

TABLE 27.1

Waste water from the plastics industry

	Type 1	Type 2	Type 3
pH	3-7	1-2	6-8
COD (g/l)	2-5	2-5	4-10
Dry matter (g/l)	1-6	2-8	4-10
Ignition residue (mg/l)	50-100	50-100	10-50
BOD_5 (mg/l)	1000-3000	200-500	200-500
Turbidity	high	opal	high
Colour	white	white	white
P (mg/l)	1-2	200-400	1-2
Acrylonitrile (mg/l)	-	-	20-200

Biological treatment and chemical precipitation

Biological treatment is used to solve the problem of waste water of type 1 (Harkness, 1964).

Waste water with the characteristics given in Table 27.1 can be treated in an activated sludge plant. The LF value is 0.4 and a COD reduction of 92% and a BOD reduction of 98% can easily be achieved.

Chemical precipitation is often an attractive solution for waste water of type 2. Calcium hydroxide is used as a coagulant, which also precipitates the phosphate. Suspended materials as well as emulsified materials will be removed by this treatment.

A waste water treatment plant can consist of the following four stages:

1. Neutralization.
2. Flocculation and precipitation.
3. Settling.
4. Centrifugation of sludge.

Table 27.2 shows the analysis of waste water type 2 (see Table 27.1) after chemical precipitation. It can be seen that the COD, BOD_5 and phosphorous concentrations are considerably reduced.

The result of this treatment is completely satisfactory. However, the temperature of the waste water might cause thermic pollution, which of course must be taken into consideration (cooling tower) before the waste water is discharged into the receiving water.

TABLE 27.2

Analysis of waste water type 2 (Table 27.1) after chemical precipitation

pH+	10-11
COD (g/l)	0.1-0.2
BOD_5 (mg/l)	20-50
Dry matter (g/l)	0.2-0.5
Ignition residue (mg/l)	40-80
Colour	none
P (mg/l)	2-10

+) Neutralization to pH <8 must be effected.

Other methods

Detoxification of cyanide can be carried out either by a stripping process or by oxidation with chlorine.

Biological treatment is possible when cyanide is present in small concentrations, but it will often be more costly than oxidation with chlorine. The solution mentioned in chapter 13 can be used for the chlorine oxidation.

Another possibility is treatment with hydrogen peroxide in alkaline solution. The following process takes place:

$$RCN + 2H_2O_2 \rightleftharpoons RCONH_2 + H_2O + O_2 \qquad (27.1)$$

In Fig. 27.1 the efficiency of this process is given as a function of time with various ratios between H_2O_2 and RCN.

In accordance with equation 27.1 the stoichiometric ratio of H_2O_2 and RCN is 2, but to obtain an acceptable efficiency a stoichiometric ratio of 3 is recommended. Increasing the temperature increases the efficiency as seen from Fig. 27.1.

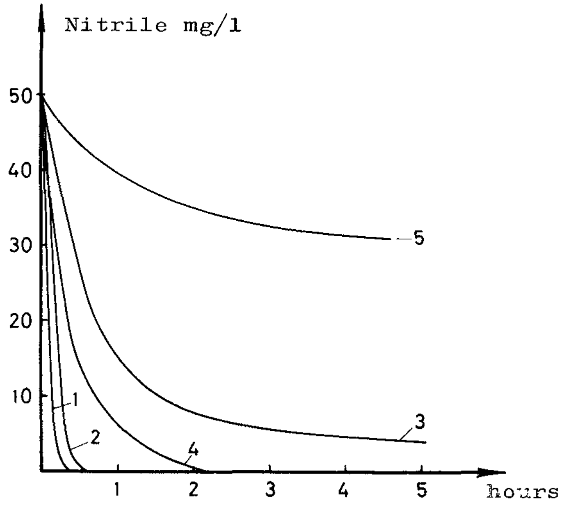

Fig. 27.1. Detoxification as a function of time.
(1) $\frac{H_2O_2}{RCN}$ = 10; (2) $\frac{H_2O_2}{RCN}$ = 3; (3) $\frac{H_2O_2}{RCN}$ = 2, all at 60°C.
(4) is the mol relation 10, and (5) is 2, both at 25°C.

REFERENCES

Dickerson, B.W., 1949. How wastes are disposed of at a synthetic resin plant. Chem. Ind., 65: 38.

Dickerson, B.W., 1949. A high-rate trickling pilot plant for certain chemical wastes. Sew. Works J., 21: 685.

Dickerson, B.W., 1950. High-rate trickling filter operation on formaldehyde wastes. Sew. Ind. Wastes, 22: 636.

Harkness, N. and Jenkins, S.H., 1964. Laboratory-scale treatment of effluent from synthetic resin manufacture. Treatment after dephonolation. J. & Proc. Inst. Sew. Purif., Part 4: 337, 382.

Kohn, P.N., 1976. New process wins acidic acid from waste streams. Chem. Eng.,: 58.