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EFFECT OF A PLASTIC COATING ON CUT FLOWERS AND GREENS

Thesis for the Degree of Ph. D.
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presented by

Charles H. Sherwood

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Horticulture

Charles J. Hammer
Major professor

Date May 9, 1957

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EFFECT OF A PLASTIC COATING ON CUT FLOWERS AND GREENS

By

Charles Herbert Sherwood

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Department of Horticulture

1957

Approved. Charles L. Hamner

ABSTRACT

The investigation relates some of the effects of a plastic coating, Vinyl latex 600, on cut flowers and florist's greens.

The plastic material, mentioned above, had a specific gravity of 1.24 to 1.25 with a solid content of 49 to 51 percent, the average size of the particle being 0.2 microns. The observations indicated that the aqueous dilutions of 10 and 20 percent Vinyl latex were effective in reducing water loss and thereby maintaining the fresh appearance of the plant materials. The treatments were particulaly effective on gardenia, plume asparagus (asparagus plumosus) and the Oregon fern (Polystichum munitum).

Respiration studies were also included. Special apparatus was designed for the purpose. A description of the same and the directions for its use are given in the text.

The observations on excised rose petals, coated with 10 percent Vinyl latex 600, indicated carbon dioxide accumulation to be 0.8 percent or about 50 percent higher than those of untreated petals. Similarly, micro-manometric determinations were also made on various plant materials, coated with or without the Vinyl latex.

Phytotoxicity and respiration abnormalities were also observed when latex, in excess of 10 percent, was allowed to dry slowly on the plant tissue.

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I. INTRODUCTION

The handling, marketing, and storage of florist greens and similar living floricultural material are often costly because of the susceptibility of such materials to bruising, wilting and physiological aging. Procedures which may reduce bruising, retard aging, or prevent excessive dessication are worth investigating. Consequently, the value of the new plastic coating material, Vinyl 600, produced by the B. F. Goodrich Company appeared to be worthy of investigation as a promising approach toward the solution of these problems.

II. REVIEW OF LITERATURE

A. General

It is recognized that a severed leaf, branch, or flower is more liable to damage from dehydration, mechanical injury or pathogens. Birch (1952), Laurie and Kiplinger (1948), and Post (1952) are among those referring to such problems as important in the harvest and use of floral crops. A considerable volume of material is available regarding the preservation of cut flowers and greens, the recent summarization by Bowden (1949) indicates that physiological aging remains an important problem.

B. Cuticle

In a very real sense the cuticle with its often naturally oily or waxy surface may be considered the last barrier or shield between the living part of the plant and its environment.

Priestly (1943) summarized the cuticle in angiosperms. Schieferstein (1955) has recently integrated the literature pertinent to the cuticle and its waxy covering. It is especially noteworthy that although a cuticle is usually present on all above ground parts including flower, stems and even roots as reported by Lee and Priestly (1924), the over deposit of wax may be undeveloped on a considerable part of the foliage as found by Schieferstein (1955).

According to Bonner and Galston (1952) the cuticle proper consists of cutin which is essentially waxes such as esters of fatty acids with long chain alcohols, keystones, and hydrocarbons containing no oxygen. The exact composition and formation is in doubt. However, it is generally

agreed that the chemical nature varies considerably from plant to plant. The development of the cuticle is also believed responsive to differences in the condition of the plant, kind and age of part, as well as the external environment. This is predicated by Klebs' classic remark that any cell possesses from its parent a definite disposition of its inner conditions through which the chemical processes are maintained in certain directions (1909-10).

Since this paper is concerned with the response of the protoplasm to artificial coatings exterior to it, the distinction between living and non-living cell wall components and cuticle components is not as important as their physiological relationships. However, it is considered pertinent that Schieferstein (1955) demonstrated that the cuticle proper is essentially varnish-like and so adherent to the exterior cell framework that pieces act as if embedded in it. His agreement with Mueller, Carr, and Loomis (1954) that the cuticle is uneven and undeveloped above where the underlying cells meet is in accord with the fissures of Crafts, Currier, and Stocking (1949) and the undeveloped parts of the cuticle described by Orgell (1955). Since the middle lamella may be considered exterior where two epiderman cells meet, it is also in accord with Roberts, Southwick, and Palmiter (1948) who state, "the amount and location of pectinaceous substances present in the leaves account for the entrance (passage) of water soluble materials such as minor elements, nitrogen, hormones, and organic fungicides sprayed on leaves." They considered this pectinaceous material as contiguous to the vascular system of the plant and to the exterior side of the cuticle.

Skoss (1955) describes the cuticle as a framework of polymerized

fatlike substance impregnated to variable degrees with wax. Skoss and many others like Bald (1952) consider the cuticle proper so impervious to materials such as spray chemicals and pathogens that the most likely passageways are the stomates. Conditions favoring positive and negative stomatal guttation cycles are considered particularly likely to result in spray injury or infection. Congestion or apoplexy of the foliage in particular is well known, the subsequent rupturing of the epidermis being termed oedema. This exposes protoplasm and favors infectious diseases as shown by Johnson (1947).

Until more information is available, the cuticle may be visualized as a film or sheet-like protective armor. The analogy of cutin and chitin is pertinent in that the cuticle of plants or animals serves similar protective purposes. Because of the polymerized and practically insoluble nature of the surface in either instance, external contact is essentially limited to stomates, pores, hydathodes and other undeveloped "cuticular" surfaces between cells or cracks and other variously scarified areas.

For the purpose of this paper the cuticle is visualized as plates of cutin extending over the surface of the epidermal cells. Although these plates may be undeveloped or scarified, stomates, hydathodes, and lenticles are large pores permitting protoplasmic contact with the external environment. However, of equal if not more importance because of the greater exposure, are the junctions of epidermal cells where the cuticle is undeveloped and the primary cell walls (characterized by the pectins and cellulose strands of the middle lamella) are variously exposed affording a passageway for both fat and water soluble materials into

the plant as described by Roberts, Southwick and Parker (1948). The occurrence of waxes and oils on the surface of the cuticle proper may be due to this inability of polimerizable precursers of the cuticle to penetrate the cuticle. Their occurrence poses the important considerations of how the waxes penetrate (if they do, is it along strands of material or through unprotected pores?) and how resistance to wetting has been found closely associated with injury from herbicides as shown by Staniforth and Loomis (1949). Since 2,4-D is soluble in either water or lipoids, the wetters could be functioning in channeling the material as well as insuring coverage.

Wylie (1930) in discussing wounded leaves and Priestly (1943) emphasize that the cuticle is much more than a means of preventing water loss. Pathogen protection is an important function. Insect injuries have been found direct passageways for pathogens. The relationship of leafhoppers to aster yellows and of two-spotted mites to mildew is known even by commercial growers. Also known is the inordinate failure of insect-damaged plants to compete with unparasitized fellow plants. Injury is out of proportion to the cuticular damage, or secondary disease parasitism. As indicated by Siefriz (1942), this regularly irritant injury may be more injurious than injury killing more tissue because of the shock duration time on the physiological activity of the protoplasm.

C. Artificially Applied Protective Coverings

The use of supplementary protective coverings to retard "drying out" and infection of severed plant parts is not new. Austen (1657) describes the use of wraps and clay to protect scion wood for journeys of several days. In grafting he mentions that the clay is as valuable to keep

moisture out as in. Most plantsmen have experimented with various mixtures containing beeswax, linseed oil, and asphalt for use as protective coatings. Commercial florists have associated mildew resistance with glossy foliage resulting from oil sprays or linseed and grease mixtures placed upon hot heating pipes.

In this literature review, two classes of protective coatings are considered; the cuticle including those materials intimately supplementing or replacing the natural cutin and the less intimate coverings termed variously as sealed-pack, prepackaged, tight wrap, etc. The first class is applied by dipping, spraying, or vaporization. The coating substance may be in a water solution, a lipoid solution, or an emulsion. The same or other materials are commonly applied in wraps. Various papers, foils, and plastic films are available for such usage.

Wildon recognized the value of melted wax coverings (1935). Chadwick (1936) describes the use of emulsified parrafins and vegetable oils. Miller, Neal, and Gardner (1945) explain the use of waxes and various wax emulsions to limit the dehydration of horticultural plants and as stickers and thinners for fruit sprays. Their paper brings together the early work Neilson started in 1928, that leading to the marketing of Dowax, and recent work regarding oil and wax coatings. Dowax is shown to be effective in reducing transpiration and in increasing the effectiveness of some fungicides and repellents both in degree and in duration. Less phytotoxic products such as Florawax (Floralife) and Bloomwax (Flower Foods) have been developed for flowers readily damaged by Dowax (Dow).

A non-lipoid material called Methylcell was credited by Felber and Gardner (1944) with protecting plants from excessive dessication.

Although it did not attain much use for this purpose in horticulture, it has been recommended for facilitating heavier deposits of more impervious coatings.

During the time these liquid wax coatings were being tried Cellophane (Du Pont) and then Pliofilm (Goodyear) became available. Several shippers were using these sheet plastics for flowers such as acacia and gardenias during the late thirties. They were also using waxed cardboard extensively.

At this time the author observed that molds were causing more damage of plant materials in transit or storage than dehydration. By 1949, cellophane was used as a wrap for cut flowers by some retailers.

After World War Two the use of sealed plastic overwraps was greatly emphasized. This was often termed pre-packaging and little or no effort was made to disguise this as other than a revolution in the merchandizing of flowers. Many florists invested heavily in materials and equipment. Few benefited and many are still critical of such packaging.

After nearly ten years of development, problems in pre-packaging flowers remain frustrating and too many promising developments have been found but superficially or transitorily successful. In the author's opinion, less than one percent of the flowers sold in 1955 were marketed as sealed pre-packaged units.

Among many recognizing the potentials of pre-packaging were Dr. Hamner and the author. However, they felt that overwraps were weak in respect to the troublesome space between the protective covering and the surface of the plant. Liquid waxes, although eliminating the troublesome space, were soft and often injurious.

In the immediate post-war period the B. F. Goodrich Rubber Company

was interested in the potentialities of the synthetic rubber resins they called Geon. These latexes varied in exact composition and were being used in waterproofing and reinforcing paper, making raincoats, shower curtains, etc. They were applicable with plasticizers, dyes, etc. These polyvinyl latexes were usually heat cured, sometimes with a pre-heat period at about 200°F. before a final curing at higher temperatures (Goodrich). However, one of these, Vinyl 600, could be successfully used at 60°F. although a minimum of 70°F. was recommended. This Vinyl 600 was considered promising for use as an artificially applied protective covering for cut flowers and greens as the film produced upon drying was firm, transparent, and flexible. Bovey, Kolthoff, Medalia and Meehan (1955) found that vinyl 600 latex is comparable to natural latex in form and concentration. Baghadi and Smock (1943) used such latexes on apples.

D. Preservative Solutions

As surveyed by Tinker (1942) many articles refer to the addition of chemicals in waters used for cut flowers. He quotes calcium as one additive of proven value for "topple". Commercially available "preservatives" such as Floralife (Floralife) and Bloomlife (Flower Foods) are useful for extending the life of cut flowers. Most of these contain a plant food such as sugar which tends to maintain the plants' metabolism. They also contain chemicals designed to control pathogens and keep the water conducting vessels functioning. Kelley and Sherwood (1955) found the better solutions resulted in a greater absorption of water. This was also mentioned by Hitchcock and Zimmerman (1929). Bowden (1949) describes the use of amino acids in such solutions as a further aid in prolonging the natural beauty of certain cut flowers.

Unfortunately these solutions are practical only when developed for average flowers under average conditions. Actually innumerable solutions would otherwise be necessary. As found by Kelley and Sherwood (1955), the kind of flower, the water used, and the additives made, interact to result in highly significant if sometimes unpredictable results. Neff (1937) indicated that the exposure of treated cut flowers influenced their response to treatment. This work led to modern packaging. It is not always practical to maintain severed material in solutions of any kind.

E. Cold Effects

In recent years, prolonged cold storage for an indefinite period was revived as a panacea for the storage problem of cut flowers and greens. The application of brominated activated charcoal described by Fisher and Keller (1951) is particularly pertinent. Fisher (1953) published an excellent paper regarding near-freezing temperatures, pathogens, and toxic gases. This type of cold storage is not, as has been inferred, desirable pre-conditioning. Prolonged storage is undesirable because some chemical processes are not appreciably retarded by such temperatures. Recent recommendations for roses have been modified from an optimistic thirty to a realistic seven days of near-freezing storage. When suitable procedures are developed for sub-zero storage, the practical storage period might be extended somewhat without seriously shortening the subsequent life after storage. Cornell (1951) has pioneered in quick freezing of flowers.

The pre-conditioning of flowers by near-freezing temperatures has been recognized as a problem by commercial florists who have long used two general methods of treatment. One was bringing the temperature up

slowly by 10°F. stages. The other consisted of submerging the flowers in water (often cold but sometimes at room temperature). Since flowers taken from cold storage often absorb water slowly, Sherwood (1953) passed on Volz' (1928) old recommendation of conditioning wilted flowers by placing the stems in warm water and allowing the water to cool.

In 1939, Maxon (1951) used vacuum to get water into thawed cuttings. Tukey, Hamner and Carlson (1945) adopted this process of getting water into cut flowers.

F. Gas Effects

The study of the effects of gas concentrations, relative humidities, and temperatures under practical conditions is complicated because each is inter-related. However, since the investigations of Kidd, West, and Briggs (1921), innumerable investigators have found that restricted oxygen availability or slightly raised carbon dioxide levels tend to prolong the life of seeds, bulbs, vegetables, meat, etc. Thornton (1930) reported that cut dahlia blooms kept at 50°F. in an atmosphere containing added carbon dioxide were not noticeably altered by a ten percent concentration of the carbon dioxide but were injured when the concentration was fifteen percent or higher. Longley (1930) and Thornton (1933) found moderately raised carbon dioxide levels prolonged the life of cut flowers. Hitchcock and Zimmerman (1929) found a humidity of 98 percent beneficial. Sherwood (1955) found lower humidities desirable in the storage of isolated flowers and flower petals. Since flowers could not remain usable in actual equilibria with even a 98 percent relative humidity, one must assume such humidities are modified considerably in the interfacial zones existing between the protoplasm and the bulk of the ex-

terior environment. A similar situation might prevail in the case of oxygen, or conversely, carbon dioxide. The environment of packaged cut flowers is largely unknown since it is extremely responsive to vectors and difficult to sample as found by Sherwood (1955).

G. Metabolism

Plagge, Maney and Pickett (1925) and later Plagge and Gerhart (1930), reported on the effects of storage conditions on the metabolism of apples. As a student the author assisted Dr. Plagge with later studies involving pre-war usage of plastic film overwraps on the respiration and aging of fruit. The importance of exact concentrations and consequently rapid measurements of many environments was readily observed. Much time was devoted to obtaining representative samples, overcoming small sealing imperfections, etc. During this period the value of analyzing smaller gas samples more quickly was often discussed.

The work of Brierly and Landon (1942) on the smothering of strawberry plants emphasized the role of metabolism and the need for controlling respiratory toxins.

H. Characteristics of Respiration

Respiration and growth have long been associated with temperature. It has been claimed that for every 10°C. change in temperature, the respiration rate is doubled or halved. However, Loomis and Shull (1937) demonstrated that the character as well as the rate of respiration was affected. Hover and Gustafson (1926) found that estimating the effect of age on respiration is complex. They found the characteristic might be high at first, then low, and finally high. They also found some plant tissue in which respiration increased with age and some in which it de-

creased with aging of the tissues. Donnely and Beck (1945) stated that the amount of respiration of plant tissue decreases with the time of sectioning, age, and loss of food.

Maskell (1928) and Denny (1933) found respiration affected by time of day with lower respiration rates at night. White (1954) found the rhythm of respiration considerably more complex with differences from seasonal effects as well as diurnal.

Robertson, Turner, and Wilkens (1947) and Whiteman and Schomer (1945) show how wounding can markedly stimulate respiration for as long as ten days. Haas (1919) found that death caused in one or two hours from lethal doses of alcohol, formaldehyde, acetone, and ethyl bromide resulted in increased apparent respiration rates as long as two hours after death. He based death as the time when the electrical conductivity jumped to six and two-thirds that of normal tissue. It is interesting to note that lethal drying resulted in the highest rates found, while death from 35°C. heat actually resulted in sub-normal rates. This was considered possibly due to enzyme destruction.

Whitehead (1934) found disease affected the respiration rate, and Denny (1948) found surface microflora also raised the apparent rate without causing visual injury otherwise. The "bounce effect" in biology which is becoming more apparent as measurements become more exacting, Aronof (1956), is further complicated by studies of various authors. Wynd (1943) found the respiration of tobacco rose greatly the fourth day after the leaf was infected with mosaic and by the time the leaf itself was infectious, ten days later, the rate had declined to less than normal.

Additives such as oils, nutrients, and growth regulators have been

found as capable of affecting the respiration rate as the solvents and laboratory chemicals previously mentioned. Stiles (1935) was one of the first to report that oils might cause either higher or lower rates. Childers (1935) pointed out that rate effects might also be apparent because the phloem translocation system was blocked by infiltrating oil.

Prill, Barton and Solt (1949) found that surface active agents retarded the growth of wheat roots in solution and the author presumes this affected at least the accumulative respiration. Hamner, Carlson and Smith (1947) found that 2,4-D treatment resulted in a significant rise in respiration the third day, with a maximum in ten days. Kelley and Avery (1949) and Mitchell, Burris, and Riker (1949) found 2,4-D at suitable concentrations might also reduce respiration. Both found other inhibitory substances. Additive and pH effects were also noted.

Barnes (1905) classified respiration as essentially aerobic, anaerobic, or fermentive. There has been an increasing amount of literature published where metabolic studies, Stiles and Leach (1952), were of critical value in living material in vivo or in vitro. Such detailed studies are invaluable in studying methods of increasing the useful life of cut flowers and greens. With such methods it may be possible to determine if growth regulating chemicals at different concentrations, times and places affect the plant material through primary or secondary effects such as the mobilization of normal plant solubles to the extent that toxic respiration by-products are locally accumulated in various quantities which then narcotize the tissue and prevent it from functioning normally. Radiobiochemistry as shown by Aronoff (1956) is especially promising.

I. Measuring Respiration

Methods of measuring respiration and the necessary equipment are described by Loomis and Shull (1937). Some particularly interesting ones were those described by Denny (1948A, 1948B, 1948C). Donnely and Beck (1945) describe a micro-respirometer and Harrington and Crocker (1923) also describe a method suitable for small samples.

The method offering the best results, if it could be mastered seemed to be that described by Wynd (1952) as a micromanometric method using modified Barcroft apparatus. Wynd (1952) describes the apparatus, calibration of it, and routine technique in detail. He points out that the limits of a significant difference are not biological but the smallest we can measure with certainty. Aronoff (1956) has also shown the need for more exacting measurements in relation to time. Wynd also emphasizes the importance of the nature of the problem in the determination of significance. The apparatus was used to measure oxygen to a few millionths of a gram. This means it was considerably more sensitive than commercially available equipment.

III. PROCEDURES AND RESULTS

A. Lengthening the Life of Cut Flowers and Floral Greens by the Use of Plastic Coatings

The most promising latex available from the B. F. Goodrich Chemical Company was distributed under the designation Geon 31X. Later the designation was changed to Vinyl 600. The early formulation was based on 25 percent solids in the vinyl resin latex. However, the bulk of the basic latex contained 49 to 51 percent total solids and had a specific gravity of 1.24 to 1.25. The specific gravity of the resin was 1.60 and its particle size averaged 0.2 microns. This is considered noteworthy because latexes with a larger particle size would require proportionately thicker applications to achieve the same uniformity of coverage. As formulated, the pH of the latex was 6.5 to 7.5. This tended to become more acid with storage particularly at higher temperatures. Storage below 60°F. could result in gelatinization which could be treated by warming the latex to 70° - 80°F. while agitating slowly to obviate coagulation.

Material stored as long as a year might serve satisfactorily while other material stored only a short while under certain conditions, such as very cold temperatures, might coagulate. The basic manufacturer recommended storage at 60° to 80°F. and usage within 90 days. Since coagulation is favored by gear and close tolerance pumps their use was discouraged.

Coagulation of these latexes were found to be favored by non-ionic and anionic systems. Therefore, spreaders, wetters, stabilizers, fillers,

colors, etc., were recommended to be non-ionic (no charge) or anionic (negative charge) in the form of dispersions, emulsions, or solutions and at about the same temperature and pH of the latex concentrate with which they are being blended. Rubber lined storage containers were recommended. Although copper and brass is harmless to the latex, they are pitted by prolonged contact.

Attempts to raise the pH with ammonia or ammonium salts may lead to discoloration of the films or coatings. However, the pH could be raised with a 10 percent solution of sodium carbonate, sodium bicarbonate, or trisodium phosphate.

Striking results have been obtained with gardenias. In the additional experiment 12 gardenias were used; 4 were dipped in a 10 percent solution of Vinyl 600, 4 in a 20 percent solution, and 4 left untreated. The flowers were then left out of water at room temperature (70° to 80°F.) and observed at intervals.

After 4 hours, untreated gardenia flowers began to wilt; and after 12 hours, in addition to being badly wilted, they had developed an objectionable yellowish brown color. Flowers treated with a 20 percent solution of Geon remained turgid and in excellent condition for about 36 hours, after which deterioration was quite rapid. Flowers treated with a 10 percent solution remained fresh and attractive for 20 to 36 hours longer than untreated flowers. It appears from this test that the 20 percent concentration of Vinyl latex 600 is best for gardenias.

The treatment with Vinyl 600 in no way detracted from the natural beauty and appearance of the flowers. It was felt by many observers that the appearance of the flowers was improved by the treatment. Some loss

in fragrance occurred from the treatment, but this loss was not great and was not undesirable.

Water loss was reduced by the treatment, and this probably partially accounts for the fresh appearance of the flowers. Table 1 shows water loss at the end of 4 hours. At this time the control flowers were beginning to wilt.

Table 1. Water loss from gardenia flowers following treatment with Vinyl latex 600.

Material	Treatment	Weight loss in percent 4 hours after treatment
No Vinyl latex	0%	13.0
Vinyl latex 600	10%	6.2
Vinyl latex 600	20%	4.5

Plume asparagus (Asparagus plumosus) is extensively used as a decorative green. However, its tendency to lose "leaflets" (cladodes) shortly after being cut is a major problem. Branches were selected, divided into 30 bundles and treated by dipping in water suspensions of Vinyl latex 600 at various concentrations. Ten bunches were treated with 5 percent Vinyl latex 600, 10 bunches with 10 percent, and 10 with 0 percent Vinyl latex 600. The branches were then placed in a warm room (85°F.) and the loss of weight recorded at intervals. Within 2 to 3 days, 20 to 30 percent of the cladodes dropped from the branches uncoated with Vinyl 600. The 10 percent Vinyl 600 treatment reduced shedding to a negligible amount over a 10-day period. As shown in Table 2, water loss was also retarded.

Table 2. Water loss from Asparagus plumosus following treatment with Vinyl latex 600.

Material	Treatment	Weight loss in percent		
		Nov. 18	Nov. 19	Nov. 20
Asparagus plumosus	0% Vinyl latex 600	0	35	66
	5% Vinyl latex 600	0	18	43
	10% Vinyl latex 600	0	5	23

Oregon fern (Polystichum munitum) is a decorative plant material that would be used more extensively if it would last longer. Fronds from Oregon ferns were divided into 30 bundles. Ten bundles were dipped in a 10 percent Vinyl latex suspension, 10 in a 5 percent suspension, and 10 in a 0 percent Vinyl latex solution. The bundles were again exposed in a warm room (85°F.) and records taken at intervals (Table 3). After about 12 hours most fronds were obviously wilting and shriveling. By 24 hours, those uncoated were past using. Those treated with 10 percent Vinyl latex 600 lasted 24 to 36 hours longer.

Table 3. Water loss from Polystichum munitum following treatment with Vinyl latex 600.

Material	Treatment	Weight loss in percent	
		Nov. 20	Nov. 22
Oregon Fern	0% Vinyl latex 600	0	60
	5% Vinyl latex 600	0	46
	10% Vinyl latex 600	0	42

A later experiment showed that 20 percent Vinyl latex 600 was much more effective than 5 percent or 10 percent concentrations. Although the 20 percent latex left a markedly glossy surface this was not objectionable on the fern.

In experiments concerning the application of Vinyl 600 latex to cut flowers and greens, it was found that seriously injured areas turned brown within 12 hours. The latex over these areas often dried a milky white indicating coagulation. Interaction of the drying latex with the plant material was suspected since immature plant material or slow drying in an enclosed atmosphere favored the difficulty. Since drying rapidly at room temperatures for at least 15 minutes precluded visible injury, work was continued on respiration rather than on investigation of phytotoxic properties. Since larger samples might dry slower and more unevenly, it was postulated that large samples should not be enclosed for at least 30 minutes after they appeared entirely dry.

It is also noteworthy, although not surprising, that two applications of 5 percent resin latex were more effective than one at 10 percent.

B. A Method for the Rapid Determination of Carbon Dioxide in Small Samples of Gases[1]

As shown by Loomis (1937) and Neff (1937), the carbon dioxide content of the atmosphere exterior to cut flowers and greens has been found an important factor in storage considerations. As mentioned previously, the author was familiar with the techniques by Plagge, in obtaining data as reported by Plagge and Maney (1941) and Plagge and Fischer (1942). In

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[1] Journal article No. 876 (n.i.) of the Michigan Agricultural Experiment Station.

general the optimum percentage of carbon dioxide exterior to stored plant material is between five and ten percent with the exact concentration dependent upon temperature, variety, etc.

Often, as when intimate wraps are used, the analysis of small samples of atmosphere adjacent to the plant material is desired. None of the various methods of determining carbon dioxide concentrations as described in the literature were considered suitable for quick analysis of numerous small samples stored in various environments. Lung and Ambler (1934) stated that an error not exceeding 0.5 percent of the total volume of the sample is obtainable in analyzing for carbon dioxide in samples no larger than one ml. in size. Although most carbon dioxide analyzing equipment features the packed tower or other complexities, Sherwood (1937) stated that the simple and inexpensive "bubble tower" is practical for small gas samples. Schafer (1938) measured carbon dioxide concentrations to 0.1 percent in leaf atmospheres with hydroxide absorption within 30 seconds. The apparatus described by Berg (1946) has the advantage of being usable for the analysis for several gases in the same small sample. Unfortunately it requires over ten minutes a sample and it is not readily usable for repeated analyses outside of the laboratory.

In some instances it is important that sudden changes in the carbon dioxide concentration be detected. Approximate values obtained by frequent testing may, in such cases, serve a better purpose than more accurate results determined at longer intervals.

The purpose of this study was to develop equipment and a procedure which permitted the determination of the approximate carbon dioxide content of one ml. samples of gas at the rate of about one a minute.

The essential parts of the apparatus (Figure 1) consist of a pipette, an absorbing chamber, and a syringe sampler. Other parts were added to facilitate repeated analysis.

To make the apparatus (Figure 1) insert one ml. pipette, graduated in hundredths, into the base of the glass T with a bit of rubber tubing serving as a collar. Attach a two and one-half inch length of thick, preferably transluscent rubber tubing to the lower arm of the glass T and insert a glass plug into the free end of this tube. To the other arm fasten a glass stopcock and then a 15-inch length of rubber tubing terminated with a glass mouthpiece. At the other end of the pipette attach a capillary tube bent in a hook shape as shown in Figure 1. A cylindrical reservoir made by removing and discarding the bottom from a test tube is attached to the capillary tube with a one-hole rubber stopper.

The apparatus is mounted with the pipette horizontal, the glass valve above, the glass plug below, and the reservoir in an upright position. This mounting can be accomplished by attaching clamps below the glass valve, on the lower arm of the glass T, and at the union of the capillary tube and pipette.

To ready the apparatus for use, put a one-inch column of mercury in the tube above the glass plug. Add a five percent solution of potassium hydroxide through the reservoir by applying suction through the mouthpiece until the solution is about one inch below the valve. Remove the excess from the reservoir and by means of the mouthpiece draw a little air in the pipette to form one or two small bubbles. Then close the glass valve. Now add a one to five percent solution of hydrochloric acid to the reservoir and draw it through the pipette by means of the mouthpiece until only

a one-fourth inch air bubble remains trapped in the pipette. Again close the glass valve. Add sufficient acid solution to half fill the reservoir vial and adjust the bubble with the glass valve (stopcock) until it just touches the zero scale mark. The level of the liquid in the reservoir should now be about that under the glass valve. A pH indicator may also be added if desired.

A one ml. syringe and a No. 26 needle make a satisfactory sampler. A tuberculin syringe marked as the pipette and of the same capacity is convenient. Since the accuracy is dependent upon the syringe and its manipulation, trial runs and necessary adjustments should be made. Outside air should be used for insuring proper sample volumes. Known concentrations of carbon dioxide gas can be used to insure accurate operation. The author found samples of exhaled breath convenient to periodically check operation under field conditions, particularly when tested samples were found surprisingly low.

The mercury serves to protect the syringe from contamination with the reagent while the sample is being injected into the apparatus through the rubber tube wall just above the glass plug. Rinsing the syringe with a one percent solution of hydrochloric acid before each sampleing will insure that the syringe will remain tight and free of alkali. The needle should be withdrawn as soon as the sample is injected as minute mercury droplets may otherwise work into the syringe.

Results of representative trials as shown in Table 4 indicate the comparative accuracy of the Micro-analyzer and the Orsat apparatus. The per-run time for the micro-analysis was less than one minute.

Directions:

To use the apparatus, set the bubble at zero. Then insert the syringe needle into the sample source and fill the syringe a little past the 1 ml. mark. Withdraw the syringe and inject the desired gas quantity into the mercury column. Withdraw the needle and ascertain the scale reading as indicated by the bubble. Open the valve and readjust the bubble to zero. The use of the mouthpiece makes possible more rapid readjustment. Close the valve and another sample can be run immediately.

Precautions:

1. The fittings must be tight.

2. The needle should be injected into the mercury. Special care in rinsing is necessary if the potassium hydroxide solution gets into the syringe.

3. The operation of the syringe should be checked occasionally. A change of 0.01 ml. in the setting may be necessary depending upon the syringe, how it is read, and the temperature.

4. The injection area should occasionally be squeezed to discourage bubbles near the valve which might otherwise be drawn into the suction line.

5. The potassium hydroxide and hydrochloric acid solutions must be maintained. Although five milliliters of solution is adequate for hundreds of samples, it should be changed monthly or as indicated by other than immediate adjustment of the bubble after injection.

Questions to keep in mind:

1. Is the sample as injected, nearly the temperature of the apparatus?

2. Is the sample representative?

3. If the bore of the pipette is rather large, will unusually rapid injection result in low readings?

Because of the small size of the sample and the rapid shuttling of the bubbles, no delay in absorption resulting from slow diffusion of the carbon dioxide in the gas phase is apparent. Reaction time, dilution of the potassium hydroxide or humidity of the sample are unlikely sources of measurable error. The dilute hydroxide is recommended as it is less dangerous than the more concentrated solutions which are frequently used. The hydrochloric acid serves to retard etching of the scale and for rinsing the syringe.

Greater accuracy might be obtainable by modifications such as using a sampling pipette instead of the syringe. Smaller samples could be more accurately analyzed by using a smaller bore pipette for the scale and bubble. Other gases could be analyzed in similar samples by the use of different reagents.

The apparatus (Figure 1) can be used with an accuracy of about 99 percent of the total sample. The use of triplicate samples will result in a greater degree of accuracy, as will extreme care.

C. The Effect of a Plastic Coating, Vinyl 600, on Carbon Dioxide Accumulation under Excised Rose Petals

The Vinyl 600 coatings on floral products as described earlier were considered by Sherwood and Hamner (1948) to be effective largely because they reduced the loss of water. However, since some treated flowers kept longer than untreated flowers when water loss was not excessive, the possibility of the retardation of physiological aging because of the accumulation of carbon dioxide under the coating was also considered. It was assumed that an external atmosphere in equilibrium with that within

Table 4. Comparative CO_2 Analysis by the Micro-analyzer and the Orsat Apparatus

Sample source	Orsat			Micro-analyzer		
	Sample size ml.	Final reading	CO_2 percent	Sample size ml.	Final reading	CO_2 percent
1	25	25.0	0	1	10.0	0
2	25	20.9	16.4	1	8.5	15
3	25	20.8	16.8	1	8.45	15.5
4	25	21.1	15.6	1	8.45	15.5
5	25	23.5	6.0	1	9.5	5.0
6	25	23.5	6.0	1	9.45	5.5
7	36	23.3	6.8	1	9.4	6.0
8	25	23.2	7.2	1	9.4	6.0
9	25	25.0	0.0	1	10.0	0.0

the petal would be more closely associated with the response of the flower than other measurements. It was hoped that the gaseous carbon dioxide content of such an atmosphere would be obtainable.

The rose petals were obtained from two partially open roses of the Better Times variety which had been kept in water at room temperature for six hours after being removed from refrigeration. Each petal was removed in sequence, the outer petals being considered the older and more mature.

Sixteen vials 2.2 cm. in diameter and 5.5 cm. in length were given a coating of rubber cement on the lip and numbered with fingernail polish. Sixteen numbered smaller vials 1.3 cm. in diameter by 5 cm. were sealed by cementing paper discs to the lip with fingernail polish. Eight of these were dipped so the paper received a coating of 10 percent Vinyl 600 emulsion. After drying, the smaller vials were inserted into the larger ones with the disc side up.

Sixteen corrugated cardboard washers four cm. square were prepared by punching round holes 1.5 cm. in diameter through the center of corrugated cardboard squares.

A moist chamber was prepared from a covered can of the type used for preserving cake by putting shredded wet paper under the rack within it.

The micro-gas analyzing equipment described by Sherwood (1946) was used for determining the carbon dioxide concentrations after different exposures. Holes in the petals made by the Number 26 needle of the sampler were sealed with a minute dab of Vinyl 600.

Sixteen rose petals were arranged in groups of four in sequence of removal from the two roses so that one group represented the older and one group the younger petals of each rose.

All petals within the particular group were randomized and two coated with ten percent Vinyl 600 on the edges and upper or inner side. This coating was allowed to dry for 30 minutes after which the large vials were covered by centering the petals on the lip with the outer side adjacent to the interior. They were further secured by centering the cardboard washers on top and securing the whole with two rubber bands, as shown in Figure 2, with firm but not crushing pressure. An additional seal of 50 percent Vinyl 600 was then run around the vial where it contacted the rose petal. The petals which had been coated with 10 percent Vinyl 600 on the upper side were then given another coat on the lower side. Each group then included two coated and two uncoated petals one of each in a large vial containing a small vial with a treated disc and one of each with an uncoated disc.

The assemblies were then put into the culture chamber and kept at 25°C. for 48 hours. All received a drop of water on the petal at 24 hours as a few untreated petals appeared to be wilting a little. A few vials were sampled at 12 and 24 hours by injecting the needle through the petal which was resealed with a minute dab of Vinyl 600.

The concentrations after 48 hours were barely measurable with the method used (Table 5). The data for a lesser period is not presented. Unfortunately, the petals were not considered in a good enough condition to attempt a longer period.

However, as averaged, the concentration found under the older petals was 0.6 percent carbon dioxide while that found under the younger petals was 0.7 percent. The concentration of the inner vials as compared to the outer showed no differences under either old or young petals. However,

coating the covering on the small vials resulted in a carbon dioxide concentration double that of comparable uncoated vials.

The average readings for petals coated with Vinyl 600 was almost 0.8 percent carbon dioxide or about 50 percent higher than the 0.5 percent found under those not coated. The difference was greatest under the younger petals.

The carbon dioxide concentrations found seem consistent with the treatments made. The 50 percent higher concentrations found under coated petals is comparable to the nearly 50 percent average decrease in carbon dioxide assimilation found under Vinyl latex coatings by Kramer (1948). It is also reasonable that the younger petals should be found to have a concentration 15 percent higher than that under the older petals. Since these younger petals were at least eight petals removed from the oldest it is not surprising that the Vinyl latex had proportionately more effect on them since the cuticle was less developed.

Although it was expected that coating the covering on the inner vial would result in higher readings of samples from the outer vial, the higher readings of samples from the coated inner vials could indicate that the levels in the larger vials had been higher prior to the test or that the sample obtained from the large vials was being diluted by incoming air mixing with it as it was withdrawn. The use of a longer needle is indicated. Since the inner vial was sampled in place, the replacement air came only indirectly from outside.

It is also indicated that the procedure is far from developed since an adequately small environment should, in the author's opinion, attain levels exceeding 5 percent under such coated petals before injury from

Table 5. The Effect of Plastic (Vinyl 600) Coatings on CO_2 Accumulation Under Treated Rose Petals (Better Times) During a 48 Hour Period After Treatment.

Treatment*		Age of rose petal treated — Percent CO_2					
		Older		Younger		Total Average	
		Large vial	Inner vial	Large vial	Inner vial	Large vial	Inner vial
1		0.8	0.0	0.2	0.0	0.5	0.0
		0.3	1.0	0.9	0.1	0.6	0.6
	Ave.	0.6	0.5	0.6	0.1	0.6	0.3
2		0.2	0.5	0.3	0.3	0.3	0.4
		0.7	0.1	0.7	1.0	0.7	0.6
	Ave.	0.5	0.3	0.5	0.7	0.5	0.5
3		0.0	0.1	0.2	0.2	0.1	0.2
		0.7	1.0	0.8	0.9	0.8	1.0
	Ave.	0.4	0.6	0.5	0.6	0.5	0.6
4		0.5	1.2	0.4	0.9	0.5	1.1
		0.8	0.5	1.5	1.6	1.2	1.2
	Ave.	0.7	0.9	1.1	1.3	0.9	1.1

*Treatments:

1. Check (neither petal nor small vial treated).
2. 10 percent Vinyl 600 coating on petal only.
3. 10 percent Vinyl 600 coating on small vial only.
4. 10 percent Vinyl 600 coating on petal and small vial.

the imperviousness of the coat would be found. Schafer (1938) found carbon dioxide levels approaching four percent in leaf atmospheres.

D. Micro-manometric Determinations

Plant materials coated with various concentrations of the Vinyl 600 latex occasionally and unpredictably developed areas which were off-color or even necrotic. It was considered possible that a sensitive method of measuring respiration might be of value in determining whether or not abnormal metabolic conditions existed following treatment and, if so, their character. Wynd's respirometer (1952) was activated and used under his direction. The experimental plant materials were rose petals of the variety Better Times and Norway Spruce needles.

The procedure used consisted of pairing the samples, one lot for treatment and another non-treated for each of the three pairs of manometers. In the case of rose petals, discs 1 cm. in diameter were punched from each side of the petal, numbered, and by random placed in either a check or treatment lot. Therefore, the manometer pair received a disc from either the left or right side of each rose petal. By trial it was found that about 6 discs were optimum for the equipment used. The discs were then treated with 0 percent to 20 percent concentration of Vinyl 600 latex and then dried at least 15 minutes before use unless otherwise noted. Spruce needles were taken from the same twig, paired or removed and treated in the manner described for the rose discs. Generally six needles were used per manometer.

In many instances the apparatus required final temperature adjustments or other care and this resulted in more than 15 minutes drying time before the samples were sealed in the vessels. As a point of caution, it is suggested that all major activities such as preparing the vessels be accomplished in advance unless a surplus of comparable vessels calibrated

for each manometer are available.

As soon as possible after an adequate drying time the vessels were capped and secured in position. The apparatus was then run for at least fifteen minutes before the arms were closed and readings begun. When the readings appeared atypical, as they rarely did, the data was scrutinized to see if the starting time was adequate and characteristic difficulties could be easily traced to a loose connection, contamination of the sample with reagent, a plugged line, etc.

The fluid in the manometers was readjusted after five hours of sampling. Sulfuric acid was used to maintain drying conditions in the vessels. This controlled fungi found troublesome at higher humidities but it usually limited total run times of uncoated controls to less than 48 hours.

The absorption of oxygen by uncoated samples indicated the samples were uniform. However, 20 percent Vinyl latex coated samples were quite variable with samples dried 25 minutes before enclosure being associated with medium low oxygen absorption rates, those dried 20 minutes with higher rates, and those dried but 10 minutes with the lowest rate of oxygen absorption (Table 6).

Determination of the effect of drying time was run with 10 percent Vinyl latex coatings on spruce needles with 10, 20, and 30 minutes drying times before enclosure. As shown in Table 7, there was no significant difference attributable to even a short 10-minute drying time when 10 percent Vinyl 600 was used. Even the preliminary temporary reduction in oxygen absorption was not as apparent when using dilute concentrations.

The 20 percent concentrations were especially consistent for short

periods when all needles appeared undamaged at the end of the experiment concerned. As shown in Table 8, the data for the full run time is quite variable.

Determinations were made to see if the 30-minute drying time previously mentioned as adequate. Insofar as immediate post-treatment is concerned, 30 minutes is sufficient drying time but some lack of uniformity in oxygen absorption was found.

Treated discs from rose petals absorbed oxygen more erratically than spruce needles. The absorption of oxygen was usually low immediately after treatment, then high, and finally low again (Table 9).

The data presented were based on dry weight. However, the data based upon fresh weights, when graphed, showed similar trends due to treatment. Fresh weights were obtained by briefly soaking in tepid water and blotting dry before weighing. All data reported produced straight line graphs when plotted on the basis of millionths of a gram of oxygen absorbed for periods of several hours and often for consecutive periods throughout the experiment. As shown in Table 10 the Norway Spruce needles lost moisture on drying to 66 hours with differences in weight due to treatment of ten to fifteen percent. The actual film of latex was less than one percent difference in weight in all concentrations used.

Table 6. Effect of Drying Time of 20% Vinyl Latex Coatings on Oxygen Absorption on Norway Spruce Needles.

Date	Time	Run Duration in Minutes	Minutes Drying Time in Open Air				
			Control	20% Vinyl 600			Control
			20	20	15	10	15
July 29	1:10 pm	70	9.20*	10.64	9.67	5.36	9.47
		80	10.48	11.98	10.74	6.27	10.76
		90	11.56	13.31	12.04	7.07	11.93
		100	12.62	14.39	12.98	8.21	12.75
July 29	5:00 pm	100	8.34	2.18	3.54	1.48	14.04
		110	9.41	2.66	4.25	1.82	15.21
		230	28.99	17.54	12.86	7.07	28.43
		250	30.28	20.08	13.33	7.41	29.95
July 30	8:10 am	10	1.07	0.847	0.59	0.57	1.64
		20	2.99	1.81	1.77	1.14	3.51
		30	5.13	3.27	2.30	1.94	5.26
		40	5.78	5.08	3.06	2.74	6.90

*Based on μl. of O_2 absorbed/10 mg. dry weight of Norway Spruce needles.

Table 7. Oxygen Absorption in µl. in Norway Spruce Needles as Affected by Protective Coatings, 10 and 20 Percent Vinyl Latex 600. Results Expressed as Percent of Control.

Date	Time	V.L. Conc. %	Drying Time Before Enclosure and Percent Oxygen Absorbed in µl.					
			Minutes	Oxygen Percent	Minutes	Oxygen Percent	Minutes	Oxygen Percent
July 29	1:00 pm	20	20	114	15	101	10	64
	5:00 pm	20		66		44		25
				87		48		40
July 30	11:00 am			117		25		44
August 8	6:00 pm	10	30	107	20	97	10	104
August 9	11:00 am			106		90		104
	10:00 pm			106		94		103

Table 8. Oxygen Absorption as Influenced by 10, 15 and 20 Minutes Drying Period in Norway Spruce Needles Coated with 20 Percent Vinyl Latex 600. Observations Recorded at Various Intervals and the Results are Experssed as ml. of Oxygen/1 gm. Dry Weight/10 Min.

Date	Interval Period	Ml. of Oxygen Absorbed at Different Drying Time Interval in Minutes			
		0	10	15	20
July 30	1:00 pm	1.43	4.86	4.02	6.88
	6:00 pm	2.42	0.92	0.41	1.14
July 31	3:00 pm	1.89	1.31	1.07	1.09
August 1	10:00 am	1.99	1.51	1.14	1.25

Table 9. Oxygen Absorption of Rose Petals,/1 cm. disc/5 hours, after Treatment with Vinyl Latex 600. Results are Expressed as Percentage of Water Dipped/1 cm. disc.

Date	Time Interval	Oxygen Absorption in ml./1cm. disc. Replications	
		1	2
July 22	3:00 pm	76	87
	8:00 pm	99	93
July 23	10:00 am	54	88

Table 10. Weight/(mgs) of 12 Norway Spruce Needles as Affected by 10 and 20 Percent Vinyl Latex 600 Concentration Treatment. Observations Recorded After Various Time Intervals.

Treatment	Weight (mgs) of the Treated Needles After				
	18	24	30	42	66
Check	101	106	96	91	80
10 % Vinyl Latex 600	104	101	100	96	88
20 % Vinyl Latex 600	107	105	103	100	95

IV. DISCUSSION

An effective, though artificial, protective coating on cut flowers and greens could be obtained with sprays or dips containing a plastic disperson, Vinyl latex 600. The use of rubber latex concentrations of 5 to 20 percent were satisfactory with the more apparent results at the higher concentrations. Injury, especially to juvenile plant material was reduced with the use of lower latex concentrations and quick drying in the open air. Data obtained indicated that 20 percent latex concentrations affected the oxygen absorption of treated spruce needles most with those dried but 10 minutes before enclosure and least those dried 20 minutes. Since the 10 percent latex treatment had little effect on respiration as measured by oxygen absorption of material dried from 10 to 20 minutes, it is considered likely that drying 10 percent treated material 10 minutes and 20 percent treated material 20 minutes after they appeared dry would be sufficient before enclosure of such material. Unless treated material is visibly dry within 10 minutes, the author considers drying conditions inadequate.

The reason for injury is unknown. The latex may concentrate more of its solubles against the plant surface while drying slowly. This concentration combined with additional penetration time before drying could well result in a greater liklihood of injury. It is also possible the cuticle itself is attacked by the latex. Another possibility is the freeing of active chlorine or other anion greatly increasing acidity with resultant phytotoxicity. The injury, appearing to be contact in character,

indicates the possibility of caustic action.

Whatever the cause, prolonged exposure of the plant surface to a latex suspension favors the injury. The coagulation of the wet latex noted on enclosed plant material may be due to excessive concentration of the latex or it may indicate one or more of the emulsifiers or a protective coating on the latex particle had diffused away or become inactivated.

The use of two applications of 5 percent or an initial application of 5 percent, followed by a stronger one is desirable. The protective coating is more effective than one application of 10 percent latex and the liklihood of phytotoxicity is reduced. The use of a small amount of trisodium phosphate in the first coat to insure a pH of 6.5 to 7.0 may be advantageous. Leeper (1955) suggested the inclusion of a small amount of a scavenger, such as organic tin added to the latex, might be helpful in reducing troubles due to excess acidity.

The erratic absorption of oxygen by treated plant material was associated with high latex concentrations and long drying times. However, even the supposedly favorable concentrations and drying times tended to suppress, raise, and then lower the rate of oxygen absorption. It is possible a transitory toxic effect was involved. A lipoid solvent possessing an appreciable vapor pressure at ordinary room temperatures might be suspected. An unsaturated hydrocarbon may be involved. The chemical or chemicals responsible might be residues or contaminants of processing. It is noteworthy that Vinyl latex 600 formulations are regularly improved (Hamner 1955) and these results were with material available by 1954.

Processing the latex with one of the positive exchange resins might

be of value if short chains of acid rubber molecules are involved. This might also avoid coagulation.

Placing the latex under high vacuum for several hours might prove of value if volatiles such as acetone are involved in the phytotoxic properties. Treating material while cooling might increase difficulties and this would suggest that direct absorption is involved. Lipoid solvents might be expected to injure more at higher temperatures.

That the film from latex treatments protects the plant is incontrovertible. Both water loss and oxygen absorption of treated material are appreciably reduced.

However, Thornton (1933), Plagge (1940) and others found that very high carbon dioxide concentrations can result in injury of the type found. The author (1940) found injury following the sudden cooling of Saintpaulia foliage which he could explain only on the possibility that respiration by-products, nontoxic at warmer temperatures, accumulated at the "rings" where injury occurred. The author also found similar injury more favored by acid than by alkaline solutions.

The possibility of toxic accumulations of carbon dioxide even momentarily occurring under a film abnormally gas tight because of a slow drying time has not been proven. The accumulation of carbon dioxide in the latex during storage is considered unlikely.

It is a coincidence that Kramer (1949) who discussed the cold-water problem with the author in 1940 also worked with Vinyl latex. He found that treated plants were briefly retarded in visible growth but that the eventual growth and yield might even exceed that of untreated plants. Using Vinyl latex 600 at 10 to 12½ percent with Dreft as a wetter, he found

transpiration of treated plants reduced as much as 55 percent the first day. However, yellow poplar transpired 10 percent more. He also found that carbon dioxide absorption was reduced over 60 percent the first day and up to 25 percent after a week. This confirms that the coat retarded the passage of both water and carbon dioxide. Since oxygen is restricted more than carbon dioxide by these films, the marked effect upon carbon dioxide assimilation may be partially explained by an over accumulation of oxygen.

Toxins such as oils have an even more marked effect on carbon dioxide accumulation than they do on respiration. Chloroplasts can be converted to leucoplasts by treatments without such marked effects on other cell protoplasm (Sherwood 1940). Therefore, the pronounced retardation of carbon dioxide assimilation following an application of a comparatively low latex concentration is acceptable. The additive effect of the Dreft is also a possible factor as Staniforth and Loomis (1949) found 2,4-dichlorophenoxyacetic acid was more injurious when used with a wetter. The intimate nature of the coat is illustrated by Hamner and Chi-kien (1948) finding Vinyl latex also increased the effect of 2,4-dichlorophenoxyacetic acid concentrations. They found that one, five, and ten percent concentrations of Vinyl latex alone had no ascertained effect on the beans treated under greenhouse conditions. This emphasized that the coat is beneficial only when useful in protecting the plant from drying winds or other adverse factors. Although the coat could be expected to hold more chemical, the marked effect is ordinarily obtainable only by placing the 2,4-dichlorophenoxyacetic acid treated control plant in a sealed container. The effect can also be partially explained as the premise that the latex, like a

wetter, favored mechanical penetration through cracks, etc. in the weakened cuticle and through the stomata. Hamner, Gartner and O'Rourke (1948) found the material V.L. 600 of decided value in retarding the water loss from cut foliage. They recommended its use to improve the keeping quality of spruce, Chinese arborvitae, and mistletoe. A later publication by Gartner, O'Rourke, and Hamner (1949) describes the latex's value in transplanting.

Vinyl latex 600 has been successfully used to coat many horticultural plants since this work was begun. Recommendations based on these studies involving its use on severed plant materials and other studies have been assembled by various distributors of the latex concentrate. The variously modified latex concentrates are now sold under such trade names as Plant Coat, Wilt Pruf and Plant Shine.

The material has been recommended for use as a spray extender and for use in foliar fertilization (Ritty 1953). Sherwood and Raun (1950) found a five percent application effective in controlling red spider. Other applications recommended utilize the film strength. Sherwood and Beck (1948) found that although the tearing strength of cloth was markedly enhanced, the unfortified V.L. 600 did not appreciably increase rot-retardant proterties. The cloth was not heat cured during coating as is done commercially with paper.

The important horticultural use of Vinyl latex 600 would seem to be as a protective coating where plants are likely to be exposed to adverse factors such as dehydration after cutting or transplanting, wind or sand burn, unusual drought conditions, and some insect and disease organisms. For example, the spraying of corn fields to prevent sand cutting during

emergence, treating red spider infested evergreens to control the spider and aid plant recovery, and usage in budding and grafting to reduce water loss and mold infections. Maxon (1951) used Vinyl latex 600 with various dyes to both protect and color cut flowers. Use with newer chemicals is being tested on cut flowers as reported by Giles (1953). This would seem promising where the chemicals, though prolonging life, do not adequately protect against dessication or mechanical damage. It is noteworthy that similar coatings in sheet form are again being adopted to commercial usage in horticulture as shown by Sweet (1952) and Mahlstede (1953).

The extensive use of the more intimate protective coatings, such as are available with Vinyl 600 latex, is imminent. Information regarding more convenient and safer techniques of application should be developed before extensive promotion is encouraged.

V. SUMMARY

The effect of a plastic coating, Vinyl latex 600, on certain cut flowers and florists greens was investigated.

An aqueous dilution of the latex in concentrations of ten and twenty percent as a foliar application was effective in retarding moisture loss. The keeping quality of the plant material was enhanced as a result of treatment with the vinyl latex.

Phytotoxicity and respiration abnormalities were observed, when the vinyl latex, in excess of ten percent, was allowed to dry slowly on the plant tissue.

An apparatus was designed for obtaining and measuring micro-quantities of oxygen in respiration determinations.

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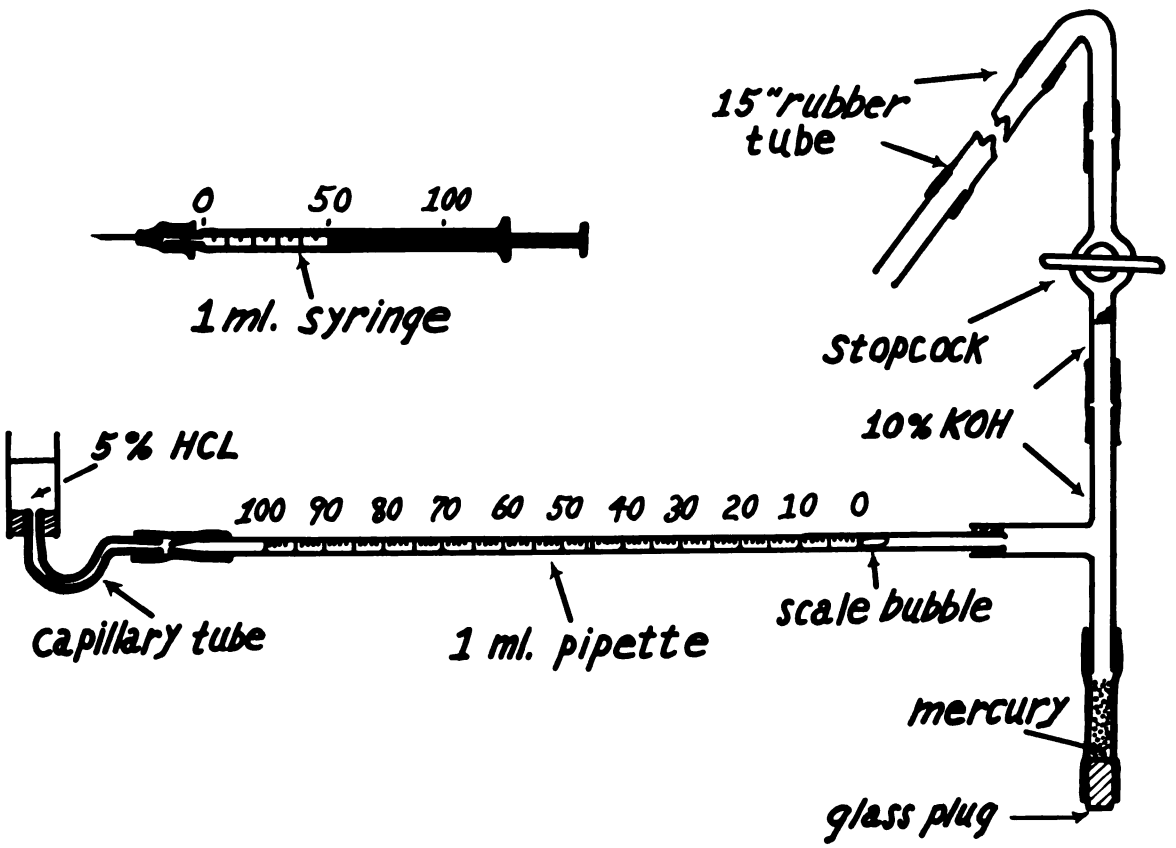

Fig. 1. Quick CO_2 evaluation equipment

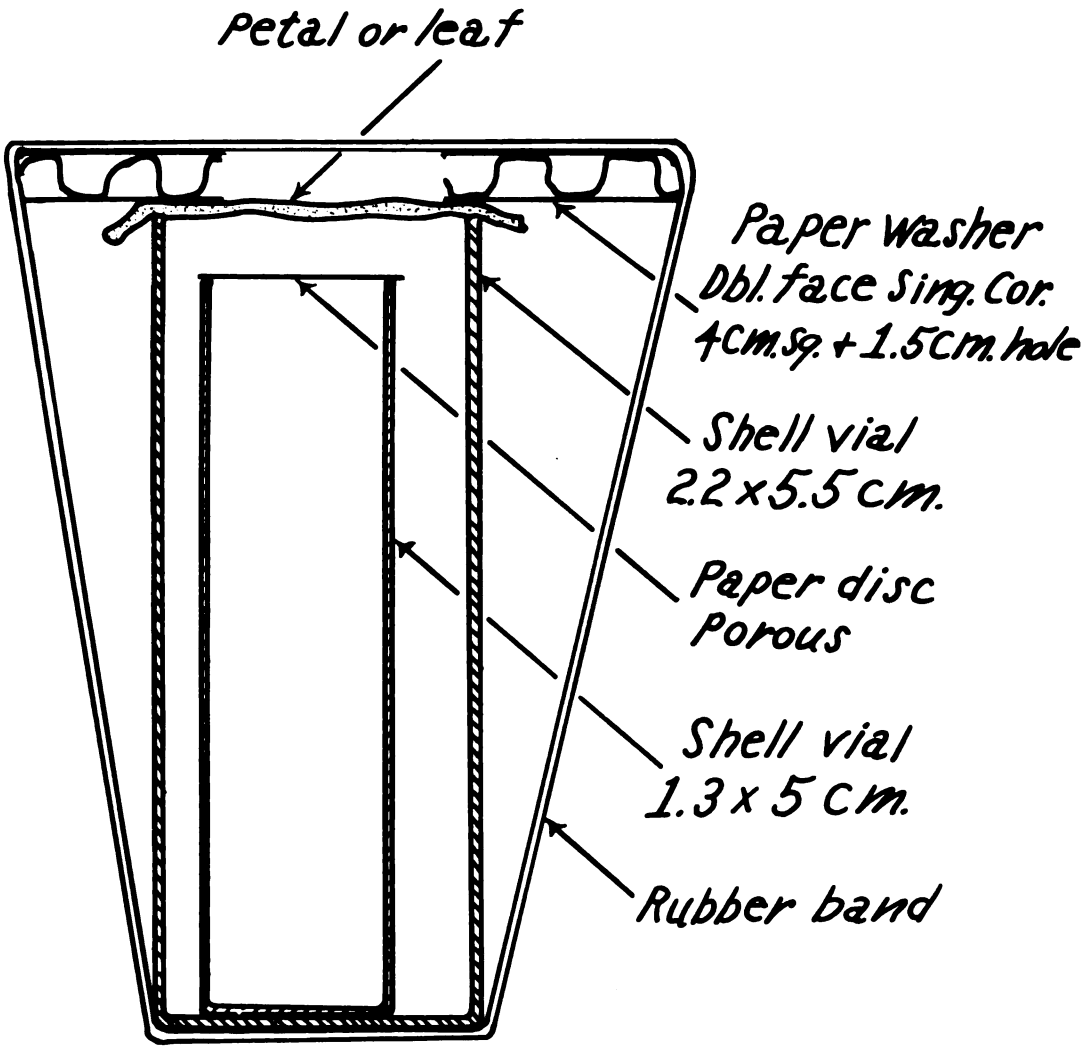

Fig. 2. CO_2 accumulator for testing efficacy of surface coatings

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