Magnesium Hydride-Mediated Sustainable Hydrogen Supply Prolongs the Vase Life of Cut Carnation Flowers via Hydrogen Sulfide

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INTRODUCTION

Floral industry rapidly developed in China. The development of environment-friendly preservatives is a challenge for researchers.

Hydrogen gas (H_2), a carbon-free energy carrier, has a wide influence in our lives from industry to medicine and agriculture since its biological effects. It has been discovered that H_2 can prolong the vase life of cut rose, carnation, African daisy, chrysanthemum and lisianthus. A major method of H_2 delivery is hydrogen-rich water (HRW). However, the practical application of HRW is limited due to the low solubility and short residence time of H_2 in water.

Magnesium hydride (MgH_2), a solid hydrogen storage material, may provide ways to improve the issues about production and storage of H_2 sinece its high hydrogen-storage capacity (7.6 wt%), abundant resources, and low cost.

$$MgH_2 + 2H_2O \rightarrow Mg(OH)_2 + 2H_2$$

- **Disdvantages of MgH_2: 1) the extremely slow reaction kinetics; 2) $Mg(OH)_2$ rapidly occured to inhibite further reaction.**
- **Some organic acids (such as citrate acid) were found as good buffer agents to effectively accelerate the reaction.**

In this study, we firstly aim to find an optimized condition for using MgH_2 in flower vase experiment. Then we tried to identify the effect and mechanism of MgH_2 on prolonging vase life of cut carnation flower.

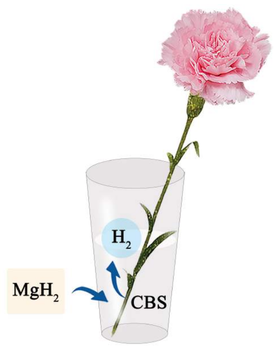
MATERIALS AND METHODS

- **Vase experiments**

  Distilled water (control), 0.1 M citrate buffer solution (CBS, pH 3.4) containing 0.01, 0.1, and 1 g L^{-1} MgH_2 (MgH_2-CBS), 10% HRW (obtained by water electrolysis)

- **Pharmacological experiments**

  Distilled water (control), 0.1 g L^{-1} MgH_2-CBS, 600 μM NaHS (a H_2S releasing compound), or 10 mM HT (a specific H_2S-scavenger), alone and in combination.



RESULTS

1. Characterization of MgH_2

As shown in Fig. 1, MgH_2 particles are spherical with the diameter of 0.5-25 μm (mean diameter = 15 μm). The amount of H_2 generated from complete hydrolysis of MgH_2 was about 1800 ml g^{-1} (0.18% (v/v); less than 4% of the lower flammability limit of H_2). Thus, it is generally safe by using MgH_2 as a vase regent.

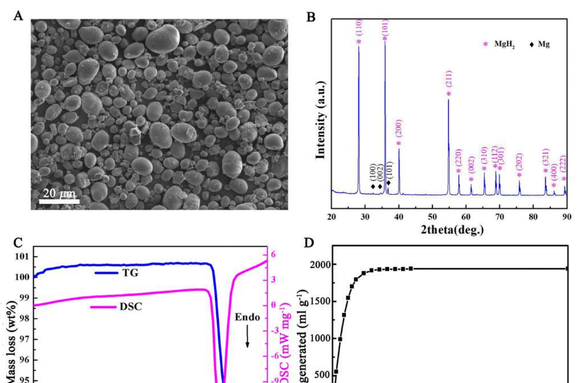


Fig. 1 Characterization of MgH_2 used in this work. (A) Scanning electron microscopy (SEM) micrographs of MgH_2 (Scale bar = 20 μm). (B) X-ray diffraction (XRD) pattern of MgH_2 powers. (C) Thermogravimetric (TG) and differential scanning calorimetry (DSC) curves of MgH_2. (D) H_2 generated from hydrolysis of MgH_2.

2. MgH_2-CBS Prolongs the Vase Life of Cut Carnation Flowers

- **MgH_2 hydrolysis, which was intensified when dissolved in CBS, and can remain higher amounts of dissolved H_2 over a relatively longer period of time than the electrolytic HRW.**
- **0.1 g L^{-1} MgH_2-CBS significantly prolonged the vase life of carnation cut flowers, compared to different doses of MgH_2, various CBS, or 10% HRW alone.**
- **The function of MgH_2-CBS is H_2-dependent.**

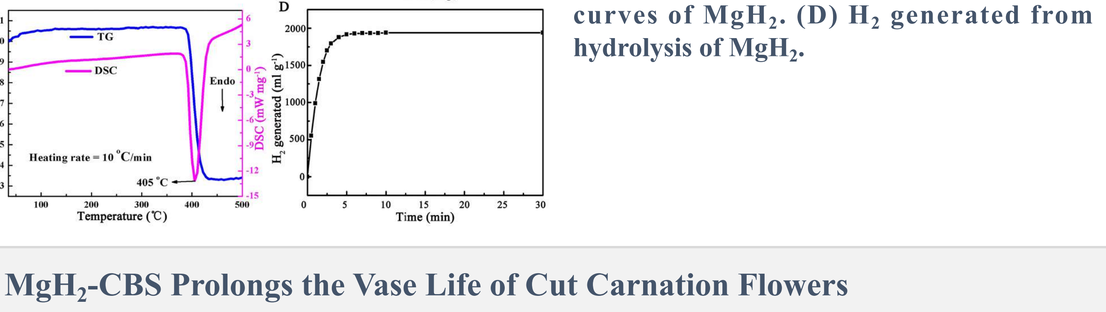


Fig. 2 Changes in vase life, relative fresh weight (RFW) and flower diameter of cut carnations and dissolved H_2 in solution subjected to MgH_2, citrate buffer solution (CBS), MgH_2-CBS, heated MgH_2-CBS, and hydrogen-rich water (HRW).

RESULTS

3. H_2S is Involved in MgH_2-CBS-Prolonged Vase Life of Cut Carnation Flowers

- **Correlating with changes in the phenotypes of vase life, relative fresh weight and flower diameter (Fig. 4), and endogenous H_2S production (Figure 3), the results indicated that endogenous H_2S might participate in MgH_2-CBS-prolonged the vase life of cut carnation flowers.**

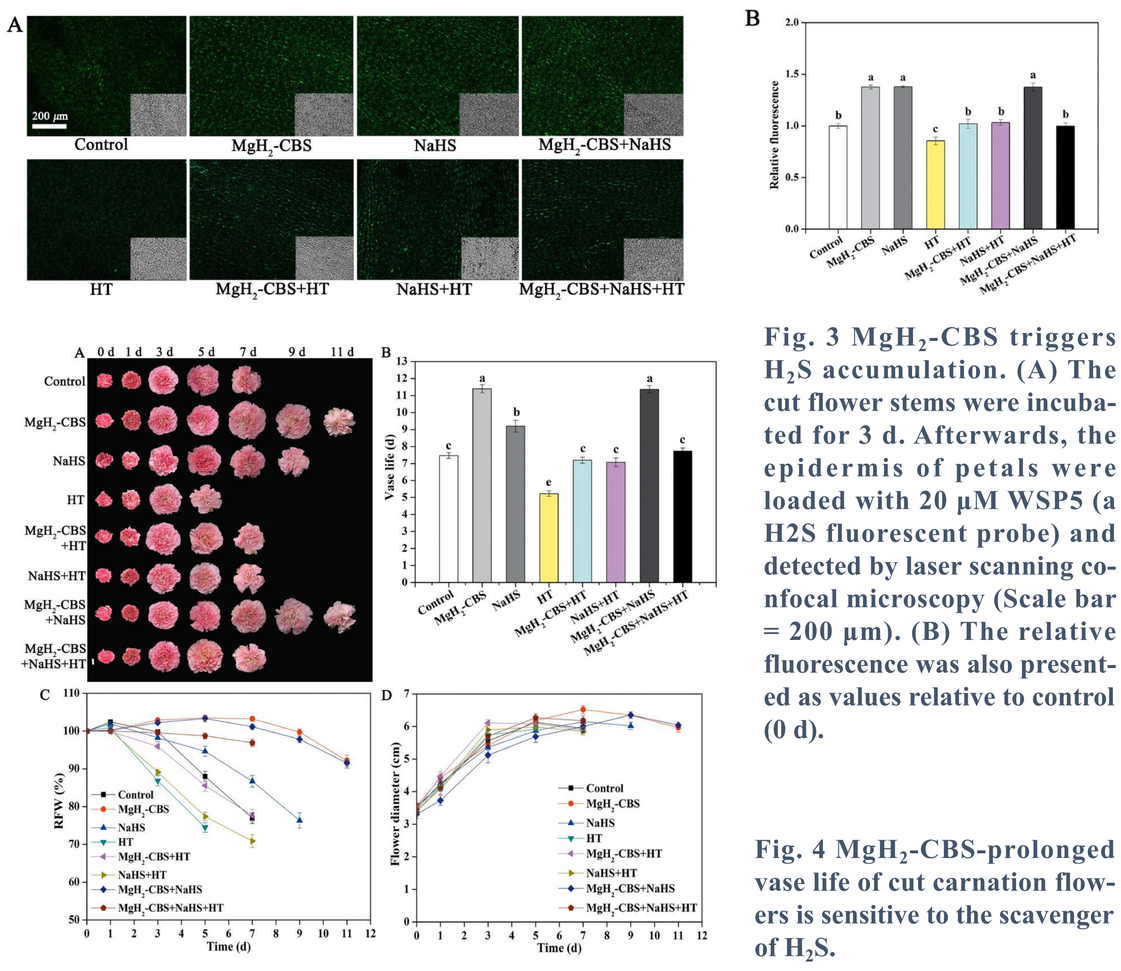


Fig. 3 MgH_2-CBS triggers H_2S accumulation. (A) The cut flower stems were incubated for 3 d. Afterwards, the epidermis of petals were loaded with 20 μM WSP5 (a H2S fluorescent probe) and detected by laser scanning confocal microscopy (Scale bar = 200 μm). (B) The relative fluorescence was also presented as values relative to control (0 d).

Fig. 4 MgH_2-CBS-prolonged vase life of cut carnation flowers is sensitive to the scavenger of H_2S.

4. MgH_2-CBS maintains redox homeostasis via H_2S

- **MgH_2-CBS-reestablished redox homeostasis was closely associated with the alteration in endogenous H_2S.**

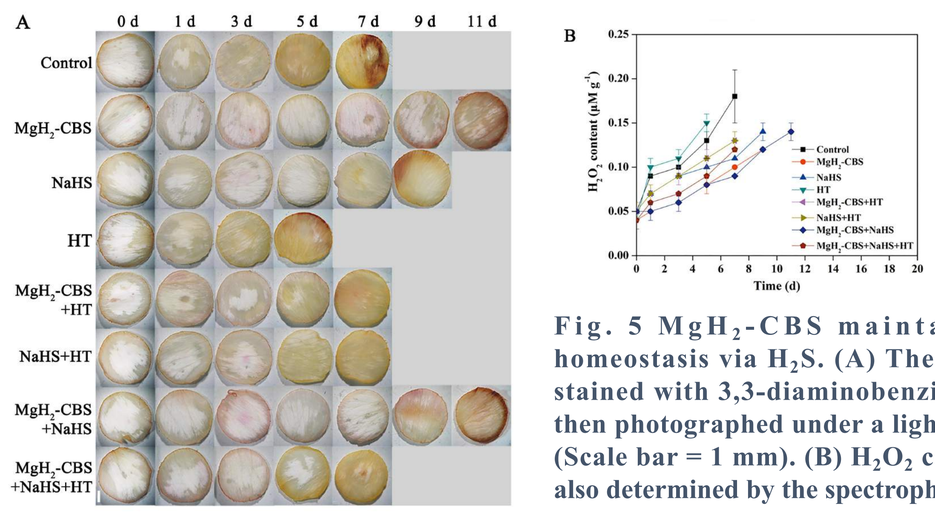


Fig. 5 MgH_2-CBS maintains redox homeostasis via H_2S. (A) The petals were stained with 3,3-diaminobenzidine (DAB), then photographed under a light microscope (Scale bar = 1 mm). (B) H_2O_2 contents were also determined by the spectrophotography.

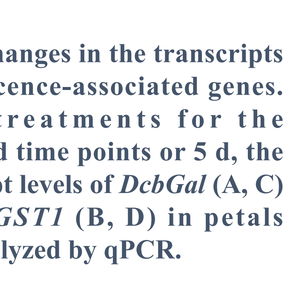
5. The role of H_2S in MgH_2-CBS-modulated *SAG*s during postharvest senescence

- ***DcbGal* and *DcGST* might be the target genes responsible for MgH_2-CBS-triggered H_2S-prolonged vase life of cut flowers.**

Fig. 6 Changes in the transcripts of senescence-associated genes. After treatments for the indicated time points or 5 d, the transcript levels of *DcbGal* (A, C) and *DcGST1* (B, D) in petals were analyzed by qPCR.

CONCLUSIONS

1. **MgH_2-mediated H_2 sustainable supply showed the positive effects on the postharvest preservation of cut flowers.**
2. **Compared to HRW, the utilization efficiency of MgH_2 was improved by buffering with CBS.**
3. **MgH_2 may have a great potential for application in horticulture.**
4. **H_2S played a vital role of in MgH_2-CBS-prolonged the vase life of cut flowers by modulating expression of senescence-associated genes.**



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