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## Spectrophotometric Determination of Trace Phosphate Ions by Amplitude-Modulated Flow Analysis Coupled with Malachite Green Method

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An amplitude-modulated flow analysis coupled with lock-in detection is proposed for the determination of trace phosphate. The flow rate  $F_S$  of sample solution is varied in response to a periodic signal  $V_c$  of alternating waveform. A coloring reagent solution (ammonium molybdate + Malachite Green) is delivered at a constant flow rate  $F_R$ . Under the constant total flow rate  $F_T$ , both solutions are merged with a diluent (water). Phosphate ion in the sample reacts with molybdate and then with Malachite Green to form green ion pairs in acidic media. Downstream, the absorbance of the mixed solution is measured at 625 nm. The output voltage  $V_d$  from the detector is sent to a lock-in amplifier, where the wave component of  $V_d$  that has the same frequency as that of  $V_c$  is distinguished from background signals. Phosphate ion can be determined from the amplitude of the component thus extracted. The calibration curve is linear ( $r^2 > 0.998$ ) and the limit of detection ( $3.3\sigma$ ) is  $0.17 \mu\text{mol dm}^{-3}$ . Compared with a conventional flow-based method with no modulation, the present method is less susceptible to the baseline drift due mainly to the adsorption of the ion-pair on the optical window, because the quantification is based not on the

absorbance itself but on the amplitude of the absorbance. Good recoveries around 100% are obtained for the phosphate ions spiked into real water samples.

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